ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XXXV., No. 23.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 361
A Curiosity in Highway Bridges (illustrated)..... 362
The Form of the Exhaust Jet in Locomotives (illustrated)..... 362
The Sewage Disposal Works of Natick, Mass. (illustrated, with inset)..... 363
The Removal of Iron from Artesian Well Water by Mechanical Filtration (illustrated)..... 364
Notes at the Electrical Exposition..... 367
Weather Report for April..... 367
Experiments with Automatic Mechanical Stokers (illustrated)..... 371
Does Pure Water Pay?..... 373
The St. Louis Tornado..... 374
Legal Decisions of Interest to Engineers..... 374
The Electric Plant of the Youghiogheny Coal Co. (illustrated)..... 375
Annual Convention of the American Water-Works Association..... 375
EDITORIAL NOTES..... 368
The River & Harbor Bill—The Form of the Steam Jet from Locomotive Exhaust Nozzles.
EDITORIAL.
Would a Rapid Transit Railway in New York City Pay?..... 368
LETTERS TO THE EDITOR..... 369
Formulas for Curved Chords—Transmission of Power by Wire Ropes—Depth of Water in the Erie Canal—The Size of Printed Specifications—The Proper Position for Sewer Underdrains—Elastic Limit of Steel Castings—Inserting Advertisements in Specifications—River Pollution at Richmond, Ind.—Errors in the Use of the Gradienter—Notes and Queries.

TWO EXPRESS ENGINES recently built by the Baldwin Locomotive Works for the Central R. R. of New Jersey, have four driving wheels 7 ft. diameter, a four-wheel leading truck, and a pair of trailing wheels under the Wootten firebox. The general design is similar to that of the Columbia type (Eng. News, Dec. 5, 1895), except that the latter has a two-wheel leading truck. The boiler is 4 ft. 10¾ ins. diameter in the barrel, and has a short combustion chamber, a firebox 8 ft. × 9 ft. 6 ins., and 278 tubes 1¾ ins. diameter and 13 ft. long. Piston valves are used, having a travel of 6½ ins. One of the engines is a Vauclain four-cylinder compound; the other is a simple engine with cylinders 18¾ × 26 ins. The engine weighs 141,000 lbs., with 80,000 lbs. on the driving wheels. The driving wheelbase is 7 ft. 3 ins.

THE FIRST OF THE TESTS OF FIREPROOFING and structural material, which are to be made by a committee of the American Society of Mechanical Engineers and other scientific bodies, were made last week, at the Continental Iron Works, Brooklyn, N. Y., where the necessary plant has been erected. The first two tests were fire tests of naked columns. The column to be tested was placed in a brick chamber, being seated on a hydraulic bearing, and having the top bearing against a heavy cross girder. A hot fire of gas and wood was maintained in the chamber and the column put under pressure, the pressures being duly recorded, while the temperatures were taken by a pneumatic pyrometer, made by Uehling, Steinbart & Co., of Newark, N. J. (Eng. News, Nov. 14, 1895). A 14-ft. Carnegie Z-bar column, 12 × 8⅝ ins., with four Z-bars and a ⅜-in. plate, collapsed by bending in a long reverse curve, near the middle. The series of tests will include naked columns and columns clothed with different fireproofing materials, which will be subjected to fire tests and streams of water. The committee includes Mr. S. Albert Reed, Chairman (for the Tariff Association of New York, as fire underwriters); Mr. George L. Heins, Secretary and Treasurer (for the Architectual League of New York); Mr. H. DeB. Parsons, Superintendent of Tests; and Mr. Thomas F. Rowland, Jr., for the American Society of Mechanical Engineers.

THE CONTRACT FOR GARBAGE DISPOSAL in New York city has been awarded to the New York Sanitary Utilization Co. for five years at $89,900 a year, in accordance with a bid received on April 27. The other bids received at that time were given in our issue of April 30. The Arnold system of reduction or utilization will be used. This system is now in operation on a large scale at Philadelphia.

SIX HORSELESS CARRIAGES started on May 30 for a competitive run from City Hall Park, New York, to Irvington and back, a total distance of 60 miles. All were gasoline engines, including four Duryea carriages, one Rogers carriage imported from France, and one Booth carriage. The start was made at noon, and the first two carriages reached Irvington at 3:15 and 3:18, both being Duryea carriages. On the return trip the first carriage reached City Hall Park at 7:13 p. m. One carriage lost a wheel and another got beyond control and ran into a woman riding a bicycle, breaking her leg. The competition was for prizes amounting to $3,000, offered by the "Cosmopolitan Magazine." A motor bicycle accompanied the carriages at the start, but was not entered for the race.

THE JOINT TRAFFIC ASSOCIATION'S CONTRACT, by which the 32 railways in the association entered into a traffic agreement, has been declared legal by Judge Wheeler, of the U. S. District Court. The bill against the agreement was brought by the District Attorney, under direction of the Attorney-General, at the request of the Interstate Commerce Commission.

ELECTRIC TRACTION on the Nantasket Beach Branch of the New York, New Haven & Hartford R. R., is to be extended, but using a third rail instead of an overhead wire as a conductor. This is for purposes of experiment as to the comparative merits of the two systems.

A BICYCLE RACK FOR BAGGAGE CARS has been designed by Mr. S. J. Collins, General Superintendent of the Wisconsin Central Lines, who considers that the bicycles are liable to injury by chafing and swinging if hung from the roof of the car. The rack is on one side of the car, and the bicycles stand on the floor, at an angle of 45° to the side. The space thus reserved is enclosed at the sides and covered by a shelf for baggage, so that the bicycles are well protected.

PREMIUMS FOR GOOD CONDUCT have been awarded to 1,299 motormen and conductors of the Brooklyn Heights Electric R. R., Brooklyn, N. Y., out of a total of about 2,600 men. The company last year set aside $10,000 to be distributed equally among the men who should have a clear record on the books for one year. The amount for each man was about $7.69.

A MUNICIPAL ELECTRIC RAILWAY is to be built by the city of Leeds, England, and the city council is now advertising for bids for the electrical plant for a double track line 7 miles long, including overhead trolley wires, underground conductors, power plant and motor cars.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision between the two sections of a parted freight train on the Pennsylvania R. R., near Sunbury, Pa., May 26th. One man was hurt, two horses were burned to death in the wreck and 15 cars were smashed.

THE EXPLOSION OF A COMPRESSED AIR RECEIVER occurred May 26 at the Pittsburg Bridge Works, Pittsburg, Pa. The receiver was used in connection with the compressed air plant in the machine shop. Two men were hurt.

A COLLISION OF ELECTRIC CARS on the Nassau Electric R. R., Brooklyn, N. Y., occurred at New Utrecht and 45th St. on May 28. A platform car ran away and collided with a crowded car from Coney Island. Five persons were injured.

THE STAMPEDE OF A GREAT CROWD near Moscow, Russia, on May 30, resulted in the death of nearly 1,000 persons. A great feast was to be given to the peasants in honor of the coronation of the Czar, and drinking cups and other presents were to be distributed. An immense crowd had collected in the early hours of the morning, before a sufficient force of police and soldiers was on duty, and the pressure from behind forced the front of the crowd against the barriers. This led to a rush and a panic, which was made worse by an attempt to prematurely distribute the gifts, the crowd then breaking down the barriers and overturning the tables, booths, etc. Those who fell were trampled on and either killed or injured.

THE PREARRANGED COLLISION at Buckeye Park, O., on the Columbus, Hocking Valley & Toledo R. R., as described in our issue of May 7, took place May 30. The engines reared up, forming an inverted V, and the cars were smashed and telescoped, the results of the collision being sufficient to satisfy the enthusiastic sightseers. The boiler pressure was low at the time of the collision, so as to reduce the danger to the spectators, but nevertheless one person had his leg broken by a flying fragment of metal. The alleged "important scientific purposes" of the collision exist of course only in the minds of the writers for the daily press.

THE NICARAGUA CANAL BILL was favorably reported by the House Committee on Commerce, on June 1; but with the date of final adjournment so near, it is generally acknowledged that it has not even a remote chance of passage. According to newspaper summaries, the report takes exception to the conclusions of the Ludlow Board of Engineers, as to the unit prices of dredging and excavation, and criticises the board's estimates for earth embankments. Instead of $133,000,000, which is the Ludlow board's estimate of the cost of the canal, the committee figures a possible total cost of $82,000,000, and expresses confidence that $100,000,000 would be an ample allowance for cost of construction, even admitting the necessity of adopting all the commission's suggestions and modifications. The committee believes that the government should assist the company to complete the work, even if it should cost $150,000,000 or more.

It is greatly to be hoped that the real friends of the canal enterprise may yet have the good sense to perceive that no government guarantee can be actually secured until an independent board examines the route and settles the points concerning which the canal company's engineers and the expert board are in dispute. The only hope for further progress in the enterprise is for the government to undertake the thorough surveys recommended in the board's report, and an appropriation for that purpose could probably have been secured at the present Congress more readily than in any future one.

SIGNALING AT SEA by means of screens, on the plan designed by Admiral Bunce, U. S. Navy, is to be tried soon on his flagship, the "New York." Racks have been erected near the military mast, extending above the turrets, and in these racks are red and white screens operated like spring roller window shades. Colored lanterns are used at night. The Myers' signaling code is employed.

MAGNETOGRAPHS taken by Prof. John S. McKay, of the Packer Institute, Brooklyn, N. Y., are similar to the radiographs obtained from the so-called X-rays, except that magnets are used in producing them. A paramagnetic substance is placed upon the sensitive film of an ordinary photographic plate and a magnet or electro-magnet brought near to the other side of the plate. A clearly defined image of the object on the plate is obtained, and this becomes a shadow in the positive taken from the negative plate. By placing the plate with its sensitive side facing the poles of the magnet, and placing a disk of iron nearly as large as the plate on the opposite side, "shadowgraphs" were obtained of non-magnetic bodies placed on the other side, between the plate and the poles of the magnet. Dark shadows were produced with a compound steel magnet weighing a little more than a pound. With an electro-magnet capable of lifting 100 lbs., a magnetograph was made through a 2-in. block of wood. The object whose image was to be impressed was placed in contact with the sensitive film. Clear images were secured in five minutes. The experiments were all made in a dark room.

VACUUM TUBE LIGHTING has developed so rapidly within the last few weeks that it would seem that the hopes of some of the most prominent inventors who are at work in this field are almost realized and that this will be "the light of the future." Mr. Nikola Tesla has announced that he has just made important improvements in connection with vacuum tubes; the final result of several years' investigation. His success has been greater than he had ever hoped. His perfected apparatus for obtaining high frequency currents is claimed to be reliable and so nearly automatic in its action as to require little or no attention; and the candle power which may be obtained is practically unlimited. "The Electrical Engineer" prints a remarkable photograph of Mr. Tesla, taken with but two seconds exposure to the light of a single vacuum tube of small dimensions. This tube had a volume of about 90 cu. ins. and gave a light of approximately 250 c. p.

Close in connection with this comes the announcement of Mr. Thomas A. Edison, that he also has perfected a vacuum tube lamp. By means of a fluorescing substance, the name of which he will not state, he is able to convert the X rays into light. This fact is of much less importance, however, than Mr. Edison's own statement that he has succeeded in producing a light of sufficient intensity to be of use commercially and which consumes only about one-third of the energy per candle power required by the present incandescent lamp. The new apparatus does not differ materially in appearance from the Crooks' tube, and retains the platinum terminals at the ends, but has no connecting filament. Mr. D. McFarlan Moore, who has been exhibiting his system at the electrical exposition, uses long tubes without metal terminals, making contact to the outside ends of the tubes. Moore, Edison and Tesla are all hard at work along this same line of producing light from a vacuum without the use of a filament and it may be only the question of a few weeks until the present system of electric lighting is revolutionized.

THE RIVER AND HARBOR BILL was vetoed by the President on May 29, on the ground that the total expenditure carried by the bill was excessive and unwarranted in the present condition of the Treasury. The President also said:

> It appears that some of the projects for which appropriations are proposed in this bill have been entered upon without the approval or against the objections of the examining engineers. I learn from official sources that there are appropriations contained in the bill to pay for work which private parties have actually agreed with the government to do, in consideration of their occupancy of public property.

The bill appropriates nearly $14,000,000 for immediate expenditure and $3,000,000 additional have been provided for in a bill already passed. The bill also authorizes the entering into contracts for works which will ultimately require over $62,000,000, of which sum about $20,000,000 would fall due on the first fiscal year ending June 30, 1898. The House passed the bill over the veto on June 2.

A CURIOSITY IN HIGHWAY BRIDGES.

We illustrate herewith a curious structure, 100 ft. in length, which spans a small stream in the city of Laconia, N. H. Just what type of bridge this is, it would take an expert diagnosis to settle. Probably its designer never concerned himself on that point. Lest our readers should fail in due respect to this curio, we will say that it has held itself up (with the aid of the pile bents beneath it) for the space of 17 long years. At the time it was constructed Laconia was not organized as a city, and the bridge was designed and constructed by an official elected by popular vote and dignified by the title of "Highway Surveyor."

THE MESSER ST. BRIDGE, LACONIA, N. H.

The bridge is not a cantilever structure, though some might so suppose from the struts at the abutments, but was erected on false-work. When it was attempted to remove the false-work, however, the structure showed a manifest disposition to lie down, and it was necessary to add the pile bents shown underneath.

Laconia is now a city, and Mr. Wm. Nelson, its City Engineer, builds bridge spans which do not call for support in the middle.

We are indebted to Mr. Nelson for the photograph from which our illustration is reproduced, and which it will be noticed gives a fine example of water reflection.

THE FORM OF THE EXHAUST JET IN LOCOMOTIVES.

By J. F. Deems; C. B. & Q. Ry.

This is simply a recital of some recent experiences as a member of a committee on the proper height and form of exhaust pipes and arrangement of draft appliances for locomotives. It was decided to fit up an engine so that the exhaust pipe could be adjusted to height from the running board by a system of levers, through a range of ins., while the engine was in actual service. A vacuum gage was also applied to assist in determining the effect of the exhaust on the smoke box vacuum as the nozzle was moved up and down. When everything was in readiness the engine was put in different kinds of service, and by noting the effect of the exhaust on the fire as the height of the pipe was altered, and also by noting the vacuum in the smoke box as shown by the gage, we finally decided on certain figures and prepared our report accordingly, adding in an appendix that the all-important factor was the relative location of nozzle and choke of stack, which should be such that the jet of steam would fill the stack at the choke at all times and thus produce the much talked of piston or pump action. In this position we seem to be well supported by the testimony of others who had tilled the same field.

As showing how generally this idea has prevailed, the committee of the American Railway Master Mechanics' Association on this subject in their report in 1894, under the head of "conclusions," has the following:

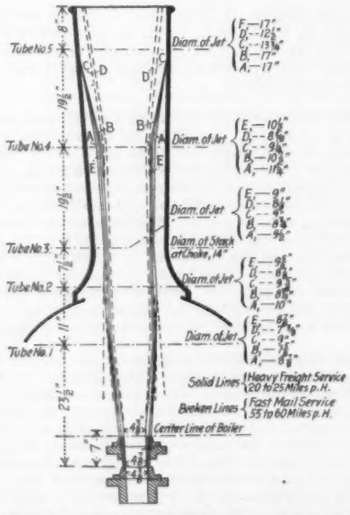
> It is important that the contracted portion of the stack and the exhaust nozzle be so located that the steam will strike the stack at or below the contracted portion; it was found that a variation in the position of the choke in a stack did not materially alter the vacuum when the steam jet struck the stack below the choke, but when the exhaust nozzle was raised and the choke lowered so that the steam jet struck above the choke, the vacuum was materially reduced.

In the discussion of this report Mr. A. E. Mitchell spoke as follows: "I have run a stack absolutely straight for 8 ins. (at the choke), so that, regardless of the position of the exhaust nozzle, I would always fill my pipe. The exhaust steam would always fill that pipe at some point in the 8 ins." Mr. A. E. Benson said:

> I have had some little experience in this matter, and I find that the secret of it is in getting your exhaust pipe down to such a point that your steam will just fill the stack. You must get that piston action in the stack. You must get your nozzle down so that the steam will expand sufficiently to fill the stack at the base and no more. But I have found on every engine in which I have put single nozzles, that the great secret of it lay in the fact of getting the exhaust pipe just high enough to fill the stack at the base.

I am sure none of these gentlemen was more firm in the faith than was our committee when we signed the report. Soon after our report was prepared a member of the committee wrote me, calling attention to a very simple device* described by Prof. Goss at the October meeting of this club, as having been used at Purdue University for the purpose of ascertaining the exact outline for the exhaust jet, and suggested that we try the same with special reference to determining the suggestion by Prof. Goss—that the jet becomes parallel before entering the stack.

An engine was at once fitted up as suggested, but instead of using one tube we used five along the path of the exhaust jet ranging from a point 23½ ins. above the tip to one 8 ins. below the top of stack, or 80 ins. above the tip.


Tube No. 5
Tube No. 4
Tube No. 3
Tube No. 2
Tube No. 1
Diam. of Jet
Diam. of Stack or Choke, 14"
Solid Lines Heavy Freight Service 20 to 25 Miles p. H.
Broken Lines Fast Mail Service 55 to 60 Miles p. H.
Center Line of Boiler

Result of Experiments to Determine the Form of the Exhaust Jet of a Locomotive.

On our first trip we tried to use the same vacuum gage we had used in our other work, each leg of which was 10 ins. long, but this would not do, as the tubes located near the choke of the stack would take all the water out of the glass the instant they were put in communication by the piece of hose used for that purpose. One of the shop men who was assisting me suggested a rather novel idea for constructing a longer gage, which proved entirely satisfactory and which I believe is worth describing. An ordinary ⅝-in. water gage glass was heated and bent into a U shape with the ends about 3 ins. apart; then by using pieces of ½-in. hose about 2 ins. long for couplings, into each end of which he inserted additional glasses, he soon had a manometer, each leg of which was 50 ins. long and before we were through with the work we found they were not much longer than needed. Instead of connecting our vacuum gage direct to the sliding tubes, we used an intermediate air chamber of about 250 cu. ins., which gave quite a steady movement to the water in the glass and enabled us to get very accurate readings. The outer ends of the sliding tubes were turned down tapering so that a piece of small rubber hose could be slipped onto them and make a perfect fit, and then, by using a piece of hose about 4 ft. long, one end of which remained connected to the drum or air chamber, the other end could be changed from one tube to another and readings taken accordingly, a record of which was kept in a log book by having the tubes numbered from one to five, begining at the bottom. We also used thumb screws to secure the tubes in position when desired, so that by changing the hose quickly from one tube to another while they were held stationary by the thumb screws, it was possible to prove the work very carefully; and I believe it is safe to say this apparatus will measure considerably closer than 1-10 in., in fact a change of less than 1-20 in. was usually quite noticeable.

The engine was put in various kinds of service, and after each trip the findings were plotted full size. The cut shows the results of several tests, grouped together for convenience of comparison. As stated before in our report we had laid special stress on the matter of having the exhaust jet fill the stack at the choke, and of course supposed we had exactly the proper relations between nozzle and stack to secure this result, and in anticipation of this had arranged the tube at that point so it could be withdrawn into a recess entirely outside of the stack; in fact we did this with all the tubes in the stack. You can imagine our surprise when, making the first trip, we found that the jet did not fill the contracted portion of the stack by from 4 to 5 ins. In fact the sectional area of the column of steam as compared with that of the inside of the stack at choke is about as 1 to 3 for the largest jet and nearly as 1 to 4 for the smallest. Furthermore we found that a vacuum ranging from 8 to 27 ins. was shown in the space surrounding the column of steam; in fact at one time when taking a "run" for a steep hill a vacuum corresponding to 50 ins. of water was shown. We also found that Prof. Goss was correct as to the column of steam becoming parallel just before entering the stack. It not only became parallel, but in most cases assumed an opposite angle from that shown near the exhaust tip, being contracted in some instances as much as 1 in. at the choke as compared with a point 7½ ins. lower down. This we found to be especially true with a stack measuring 13 ins. at the choke instead of 14 ins., as shown in the sketch.

The solid lines of the sketch show the form of the jet in heavy freight service at from 15 to 20 miles per hour, while the broken lines indicate fast express service at 55 to 60 miles per hour. Readings were taken for the nozzle in the highest and lowest position in all kinds of service. The solid lines AA show the result with the nozzle in the lowest position, or 42 ins. from choke of stack when running about 20 miles per hour in heavy freight service, while the solid lines BB were produced with the nozzle in its highest position or 35 ins. from choke of stack under the same conditions. It will be noted that the angle is practically the same, but the column of steam is about 2 ins. smaller in diameter up to tube No. 2, while from there to the choke the column is parallel instead of being contracted as in the former case, but approaches more nearly the same diameter at the choke, and that this difference is maintained to tube 4, 61½ ins. from nozzle, but from there to the top of the stack they are practically the same. It will be noted that after passing this point the expansion or divergence of the lines is very rapid and the stack is filled at a point somewhere near 8 ins. from the top, from which it would seem there cannot be much of the piston action; and when we come to consider the broken lines C, C and D, D which represent a speed of from 55 to 60 miles per hour in express service, there certainly can be none of it, as in this case the steam jet does not fill the stack at any point by several inches, or at least it lacked several inches of filling it 8 ins. below the top, and unless the expansion was very rapid above that point it did not fill it at all. Yet with this condition a much higher average vacuum was shown than at the lower speeds where there is possibly a slight piston action near the top of the stack, the vacuum quite often reaching 20 ins. and seldom less than 12 to 13 ins. at the choke and a considerable vacuum was shown for each of the tubes above the choke, being as much as 3 ins. at the one near top of stack and 7 ins. for tube No. 4. The solid lines EE show the result of enlarging the opening of the tip ½ in. gives a result quite different from any of the other conditions.

After going over the work carefully with a 14-in. stack and being convinced that the exhaust jet could not be made to fill it under any ordinary service conditions, the question came up as to what would be the result if the diameter of the stack were reduced and we applied one 13 ins. diameter at choke only to find that the jet was proportionately more contracted as it approached this point, or with the conditions the same as those that

*Abstract of a paper read before the Western Railway Club at the meeting on April 21. Some remarks on the subject will be found on our editorial page.

*Eng. News, Nov. 28, 1895.

produced lines A, A with a 14-in. stack we found we got lines approximately the same as A, A to tube No. 1 and not differing much from there to tube No. 2, but from that point to No. 3 there was a marked difference, as the lines contracted about to the point shown by lines B, B at tube No. 3 which seems to show that the more the diameter of the stack is reduced, the more the jet will be contracted to meet the conditions. I did not plot this line on the sketch, as I feared so many lines would be rather confusing.

From what experiments we made, it seems certain that with every change of exhaust opening, every change of distance between the exhaust tip and stack, whether by altering exhaust pipe or stack, or with every change in diameter in stack, comes a change in the form of the exhaust jet; and it seems possible that, if proper relations are once established, one part should not be altered without some change in the others in order to obtain the best results. It would also seem to be true that during a trip of 100 to 150 miles, especially over a line with varying grades, with any given arrangement of draft appliances the form of the exhaust jet undergoes hundreds or perhaps thousands of changes, being appreciably influenced by every change of cut off, every variation of speed, or possibly by a change of steam pressure, or difference in the volume of air admitted to the tubes, either owing to the condition of the fire on the grates or irregular opening of the fire-box door.

Another point which seems possible, but which our experiments did not cover, is that owing to the different paths by which the gases approach the choke of the stack and consequent difference in the force with which they impinge against the jet, it may lack considerably of being circular at that point. Another thought that occurs when looking at these lines, showing such a great difference in the form of the jet at high and low speeds, is that possibly the best results can only be obtained by very different construction for the two classes of service.

Prof. Goss (Purdue University).—While we are making a very extended series of experiments to determine the form and density of the exhaust jet, the work is not yet complete and hence conclusions should not be drawn. I may say, however, that the results which we have, are entirely in accord with those which have been presented by Mr. Deems. We have been able not only to trace the boundary line of the steam jet, but also to establish a series of curves within the jet, each curve being drawn between points having the same velocity. We also have good evidence concerning the non-existence of the "pump action." This was shown by blocking our slide valves clear of their seats and by opening the throttle until the exhaust pipe pressure equaled that which we found to exist there while the engine was running. The result was a steady blow of steam from the exhaust tip and this gave as good a draft as that obtained by running the engine. It is quite evident that the form of the jet depends upon the character of the surrounding mechanism. The jet begins to do work upon the gases surrounding it the instant it leaves the exhaust tip. Investigations show that there is a rapid movement of gas from points below the level of the tip, upward toward the jet. The gas everywhere tends to move in line with the jet, and the jet requires gas to work upon even after it has passed up into the stack. This explains why there is a strong vacuum at the base of the stack, as has been found by Mr. Deems.

The cross section of the jet is less at the choke of stack than at points lower down, because the gas which is to supply portions of the steam jet at points near the top of the stack must pass into the stack at the base. This current of gas crowds the steam jet and at the choke actually narrows it. I should say, therefore, that the reduced section of the steam jet which appears on Mr. Deems' drawing is due to the reaction of surrounding currents of gas.

THE SEWAGE DISPOSAL WORKS OF NATICK, MASS.

(With inset.)

The topography of Natick and its location in regard to a portion of the Boston water supply, and also the supply of smaller communities, renders it necessary to both pump and purify the sewage of the town. For convenience and economy of operation a small reservoir has been built for storage. Natural conditions favored intermittent filtration as the means of purification, the most available location being across a country road from the disposal area of South Framingham, Mass.*

Natick lies about 17 miles westerly from Boston, in the drainage areas of the Charles and Sudbury Rivers. The natural drainage of the most thickly settled portion of the town is into Lake Cochituate, principally through the north and south arms of Pegan Brook. The natural outlet for sewers would be into Lake Cochituate, but this is a part of the water supply of Boston. Another possible outlet is the Charles River, but this is drawn upon for a water supply by some half dozen towns below. The outlet from Lake Cochituate, below the intake of the Boston water-works, is the most feasible outlet, as on the Sudbury River, below, there are no water-works intakes, but even with this outlet purification was deemed necessary.

The population of Natick in 1890 was 9,118. A public water supply was introduced by the town in 1874. In November, 1885, Mr. Eliot C. Clarke, M. Am. Soc. C. E., Engineer to the Commission on a General System of Drainage for the Valleys of the Mystic, Blackstone and Charles Rivers, recommended in his report (pp. 187-9) that a joint sewage disposal system be built for the towns of Natick, Framingham and Ashland, and the Sherborn prison, with disposal on the land since selected by Natick and Framingham for this purpose. These two towns have acted separately in the matter, Framingham completing its sewerage and sewage disposal system in

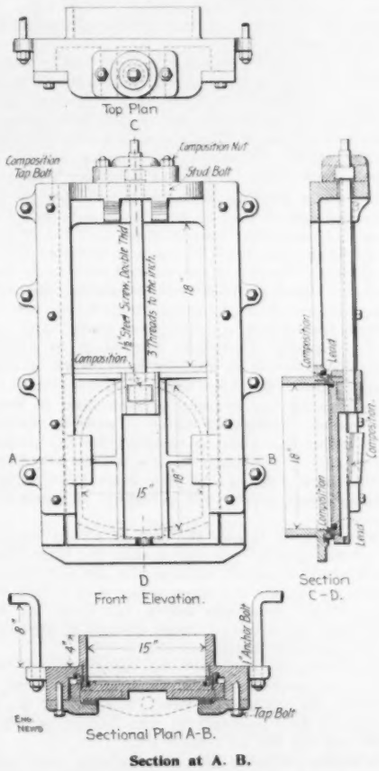


Fig. 6.—Details of Slide Gate for Reservoir and Screen Chamber.

1889, but Natick only putting its system in operation this year.

At the March town meeting in 1891, Natick decided to engage Mr. W. E. McClintock, M. Am. Soc. C. E., of Boston, to make surveys and plans for sewers and sewage disposal. Nov. 1, 1891, Mr. McClintock reported on the subject, with estimates of cost. He followed the general recommendations of Mr. Clark in the matter of disposal, and outlined the main features of the outlet sewer, reservoir, pumping station, force main and filter beds. Twelve acres of filtering area were recommended for the start, with one underdrain to each bed.

Mr. McClintock's report was accepted by the Sewerage Committee and submitted at the next town meeting, in March, 1892, without recommendations.

No work was done at Natick until 1895, when construction was started with Mr. Samuel M. Gray, M. Am. Soc. C. E., of Providence, R. I., as engineer. We are indebted to Mr. Gray for the accompanying illustrations and the following information: The sewage will be brought to the pumping station through a 30-in. circular brick sewer and a 24-in. cast-iron pipe with leaded joints. The 24-in. pipe was used near the head of Lake Cochituate, to prevent any possible leakage into the lake, as the water is used by the city of Boston for domestic purposes.

At the pumping station there are a screen chamber and house, receiving gallery, reservoir with three separate compartments, two pump wells, two horizontal tubular boilers and two vertical compound duplex pumps. A plan and details of the pumping station, reservoir and accessories are shown by the inset sheet and by Fig. 6, in the text. Water for condensing purposes and boiler use will be taken from the pond through the 6-in. pipe, shown in Fig. 1. The reservoir and pump wells are ventilated by a connection with the chimney, as shown in Fig. 2, so arranged that the gases may be turned either into the smoke flue or the space between the flue and outer walls of the chimney. Mr. Gray describes the pumping station, reservoir and force mains, as follows:

> After the sewage reaches the screen chamber, it passes through iron bars placed ¾-in. apart; it can then be turned, either into the reservoirs for storage, or into the smaller pump well and pumped directly to the filter fields, in which case the pump can be regulated to take the flow, thereby saving the lift which would be necessary if allowed to go into the reservoir. The reservoirs have a combined capacity of 500,000 gallons. In designing this plant it was intended that the night and Sunday flow of sewage would be stored in the reservoir, and that the small pump could be used for pumping the daily flow for about eight hours per day, while the larger pump could be used for discharging the reservoirs at the same time.
>
> The sewage is delivered onto the filter fields through 8,000 ft. of 16-in. cast-iron pipe, laid on a grade throughout its entire length, which enables the contents of the force main to be entirely drawn back into the pump well whenever necessary to clean the pipe.

A slide gate used in the reservoir and screen chamber is shown by Fig. 6, in the text. The city bought 97½ acres of land for a disposal area, 74 of which can be made available for filter beds. The land is described as follows by Mr. Gray:

> This tract of land was covered with a small growth of wood and brush, part of which has already been cleared. The soil is of a sandy nature, and generally well adapted for filtration purposes, although we have encountered in some of the beds a thin layer of sandy clay, which, in my opinion, will render it necessary to lay underdrains. The effluent from the underdrains will be discharged into a small stream, which empties into the Sudbury River below the lake.

Mr. Gray recommended the preparation of twelve acres of filter beds before the plant was put in operation, these to be underdrained with 3-in. tile, 36 ft. apart, laid on a grade of 0.2%, and extending 96 ft. each way from the central 8-in. main drain, shown on the filter bed in Fig. 4.

Only two beds of one acre each were prepared in 1895, and from these the 3-in. underdrains were omitted. On June 1, 1896, Mr. G. L. Bartlett, Clerk of the Sewer Department, wrote us that another bed had been prepared and the underdrains put in; also that several other beds were partially done, and would be completed as needed. The details of one of the beds, with the 3-in. underdrains omitted, are shown by Fig. 4.

*See Eng. News, Nov. 23, 1880; Aug. 11, 1892; Feb. 25, 1893, and Feb. 13, 1896, for a description of this plant and details of its operations.

A COUNCIL OF ORDNANCE is proposed by a bill which has been introduced in Congress, as a substitute for the present Board of Ordnance and Fortifications. The bill provides that the Council shall consist of seven persons, to be appointed by the President, and confirmed by the Senate. Two members are to be officers of the Army (selected from the Corps of Engineers and the Ordnance Department); two are to be officers of the Navy, and the other three are to be civilians. The members are to be chosen with reference solely to their character, experience and acquaintance with the principles of mechanics, metallurgy and chemistry as applicable to questions of ordnance and gunnery. The military and naval officers are to be relieved from other duty while acting on the Council. The term of office of four members, to be selected by lot, is fixed at four years. The term of the three remaining members and of the successors of those whose terms of office shall expire is to be three years.

COMPRESSED AIR TANKS for inflating bicycle tires are in use in Rome, N. Y., the apparatus being the invention of Mr. T. H. Stryker, of that city. The tank is about 12 ins. diameter and 5 ft. long, and has a ¾-in. pipe with two globe valves, a hose connection being fitted to the pipe below the second valve, while a pressure gage is placed between the valves. The lower valve is first opened to the atmosphere, and the hose coupled up to the nipple of the tire. The second valve is then gently opened, giving a pressure of 35 to 40 lbs. The tank is charged at about 200 lbs. pressure. One such tank will inflate about 500 tires, and the tanks are delivered by the maker ready for use, and taken back when empty to be recharged.

THE REMOVAL OF IRON FROM ARTESIAN WELL WATER BY MECHANICAL FILTRATION.

Many people consider artesian or other deep wells as an ideal source of supply. The popular impression is that such water is cool, clear and notably pure. It often happens that such water is cool and clear, and that it is pure, so far as contamination from organic matter is concerned, although the water from some pretty deep wells has been found to be polluted with sewage or similar wastes. But however good deep-seated waters may be, judged by common standards for water from other sources, it not infrequently happens that they contain some mineral salts which render them either utterly unavailable for domestic and industrial purposes or only available after some means of purification has been adopted. Notable instances of such waters occur along the New Jersey coast, where many artesian wells successful as to quantity have been put down in recent years, but the waters of some of which are so impregnated with iron compounds as to render them unfit for use in their natural state.

Since the latter part of 1893 there have been put in operation three mechanical filter plants for the express purpose of removing iron from artesian well water in New Jersey, one each at Atlantic Highlands, Asbury Park and Keyport, N. J. The mechanical filters employed were not different in themselves from others of the same type designed for treating other classes of water, but some important modifications were made to adapt the Keyport plant to its work, and special conditions exist at Asbury Park, independent of the filter plant, which seem to have added greatly to the efficiency of filtration. The plants at Atlantic Highlands and Asbury Park were built before that at Keyport, and will therefore be described first. The filters in use at these two places are known as the Continental and the Keyport filter is of the Warren type.

The Continental System of Mechanical Filtration.

The following general description of the Continental filters in use at Atlantic Highlands and Asbury Park, has been furnished by Mr. David Williamson, Engineer of the Continental Filter Co., 44 Wall St., New York city:

> Double filtration is employed, all water passing through two filter tanks in succession. The first tank contains a bed of fairly coarse, sharp sand, and the second a bed of specially prepared fine material, each bed being about 3½ ft. thick. All water thus passes through an aggregate depth of filtering material of about 7 ft. Downward filtration is employed. The company recommends and prefers to install filters of the pressure type, but is prepared to erect gravity filters when desired. The filters at Asbury Park and Atlantic Highlands are of the pressure type. No chemicals are used at either of the two plants under consideration. The company claims that it can handle waters of almost every class without a coagulant or chemicals of any sort.
>
> When the filter beds are clean there is no appreciable loss of pressure due to the passage of the water through them. As the beds become clogged the resistance gradually increases, and when it reaches from 2½ to 5 lbs. it is an indication that the filters require washing. This back pressure need never exceed 5 lbs., but the frequency of washing the beds is optional with the operator.
>
> The process of washing out the filter beds is effected by reversing the current of water, compressed air being also passed through the beds in large quantities during the process. A 10,000,000-gallon plant would not require more than 150 cu. ft. per min. About 30 minutes are required for washing two filter tanks with a capacity of 1,000,000 gallons per 24 hours. The company will guarantee that the amount of water required to wash a filter with a capacity of 1,000,000 gallons a day does not exceed 7,000 gallons, and that its method of washing the filters is absolutely efficient and thorough.

The largest of the two Continental filter plants is at Asbury Park, but the first to be put in operation was at Atlantic Highlands. These are the only two city plants of this type yet put in.

Continental Filter at Atlantic Highlands, N. J.

Atlantic Highlands is a coast town near Asbury Park and Long Branch, which had a population of 945 in 1890. The town built water-works in 1893, pumping a supply from artesian wells direct to the consumers, the surplus going to a covered stand-pipe with a small elevated tank on top of it, for high service. The stand-pipe has a capacity of about 178,000 gallons, and the tank of about 20,000 gallons.*

The following information regarding the water-works system and the filters was obtained by the writer from Mr. W. W. Roberts, engineer of the pumping station, during a visit to the works Dec. 4, 1895:

*An illustrated description of these tanks was given in Engineering News for Sept. 7, 1893.

Eight wells are now in use, four having been added since the plant was started. The first well sunk was 460 ft. in depth, but the others range from 108 to 112 ft. deep. All the wells were 4½ ins. in diameter, cased down to strainers each 3½ ins. in diameter and 40 ft. long. The original wells are connected with a 10-in. siphon collecting pipe emptying into a receiving well. The later wells are connected with an 8-in. pipe which joins the siphon near the receiving well. The siphon leg is 6 ins. in diameter and 20 ft. long. The receiving well is 20 ft. in diameter and 22 ft. deep, and has in its bottom a small well or sump 8 ft. in diameter and 4 ft. deep, into which the siphon leg extends. The big well is lined with a brick wall in cement and covered with iron or steel beams and brick arches. The bottom of the well is in its natural condition, as excavated, and being in sand a considerable amount of water comes into it. During construction a pulsometer pump was used to keep the excavation dry, the estimated pumpage at times being 550 gallons per min. In the summer the infiltration is less than during the remainder of the year, falling off with the lowering of the ground water level. The available storage capacity of the well is given as 32,000 gallons.

The filter plant was put in operation in October, 1893. It has a daily capacity of 500,000 gallons, and is located in a one-story extension to the pumping station. The filters generally work under a pressure of 122 lbs., with a loss of head of 8 lbs. With full tanks the working head is 131 lbs. Each filter is 6 ft. in diameter and 11 ft. long. The filtering material in the first tank is crushed quartz, and in the second is animal charcoal. About eight bags of sand and five of charcoal have been used to replace material lost by washing. The filters are washed once in 24 hours when worked to their full capacity. When the plant was visited, the pumps were being run only about four hours a day, and each tank was washed every other day, equivalent to washing once in 48 hours. In washing both filters, only nine valves and two levers need be manipulated, and this permits the washing of each filter in halves if desired. Unfiltered water is used in washing and about one hour is required for the process. Some care is necessary to prevent the wasting of the animal charcoal in the wash water, but it appears that this is not a matter of much difficulty.

Mr. Roberts thinks the use of air in washing is advantageous. He states that the filters were used about a month without the air and that on resuming its use the wash water had a very bad odor. The compressor has a 12×12-in. air and 8×12-in. steam end, a large volume of air under a low pressure being required.

No chemicals are used, no extra labor is employed to operate the filters, and there was no expense for repairs last year. The cost of the filter plant and foundations was $4,850, of which $400 was for the air compressor.

It seems probable that the artesian well water is much diluted by the infiltration of the receiving well through a considerable part of the year, thus rendering less difficult the task of filtration. In summer, when the ground water level is low, and thus the infiltration less, it is harder to remove the iron from the water than at other times. The iron at Atlantic Highlands is said to be in a different form than at Asbury Park or Keyport.

The Continental Filters at Asbury Park.

The second Continental filter was put in operation at Asbury Park on Jan. 11, 1895. It has a capacity of 2,000,000 gallons, and is of great interest, owing to the careful studies of its operation which have been made, and the fact that the use of Pohle air lift pumps to increase the flow from the artesian wells thoroughly aerates the water before filtration and greatly aids in removing the iron, although it does not appear that this was taken into account when filtration was adopted.

Asbury Park is a well-known seaside resort not far from New York. Its population is not separately given by the United States census, but it was estimated at 3,500 in 1890. The summer population is, of course, larger. The water-works were built by the borough and were put in operation in June, 1886. The supply has always been from artesian wells, but a number of different wells and combinations of wells have been tried to secure the necessary quantity and desired quality of water. The first five or six wells were 425 ft. deep, and now yield so little water that they are not drawn upon. Next, seven wells were sunk to a depth of 600 ft., these having a 4½-in. casing. Later, two much deeper wells were put down, one 1,021 ft. deep with a casing 6 ins. in internal diameter, and the other 1,132 ft. deep, with a 10-in. casing. These wells are known respectively, as the 1,000 and 1,100-ft. wells.

The 400-ft. wells flowed slightly at the surface, but so many were put down that they interfered with each other. Some of the 600-ft. wells gave a fair flow and others did but poorly. The 1,100-ft. well gave a flow of about 175, and the 1,000-ft. of about 125 gallons per min. at the surface, or a total of 430,000 gallons a day. These wells discharged a less amount at the level of the receiving tanks.

The 400 and 600-ft. wells yield water containing some iron and the deeper ones are so impregnated with it as to render their use impracticable without removing the iron. The 1,000-ft. well was sunk in 1893, and the 1,100-ft. in 1894. An attempt was made to use the water from the deep wells notwithstanding the iron, and then to use these and the 600-ft. wells together, but so much trouble arose that finally the deep wells were drawn upon only when the 600-ft. wells were insufficient. Iron was deposited in the mains, and when these deposits were stirred up by fluctuations in the current, the concentrated iron solution drawn from house faucets seemed to the consumers unbearable. It was thought that vigorous flushings of the mains would prevent or at least alleviate, the trouble, and at periods the water-works force actually worked night and day in response to the complaints that came from every mouth.

Investigations for a new supply from some other source were instituted, having in mind not only better but more water. Men with mechanical filters to sell declared that the iron could be removed by their methods. Dr. Thos. M. Drown, now President of the Lehigh University, was called upon by a joint committee of Asbury Park and Ocean Grove to give an opinion on the matter. He stated in a most interesting report (see Engineering News of Jan. 25, 1894), his belief that aeration followed by filtration would effect the desired result. Mr. Parker N. Black studied the possible sources of supply, surface and artesian. He found no available surface supply and suggested sinking still deeper wells. One was extended to 1,300 ft., but an accident prevented conclusive results. Finally, Mr. Black recommended trying the air lift pump, and this gave so good results that it was adopted for use on the seven 600-ft. and the two deeper wells. Bids for mechanical filters were invited and a contract finally awarded to the Continental Filter Co., but the company states that this was before the air lift pumps were adopted.

The air lift pump has been applied to all the 600-ft. and to the deep wells, ¾-in. air pipe being used in the 600-ft. and 1-in. in the deep wells, the pipe extending down 200 ft. in each well. The yield from the two deep wells with the use of air is said to be 1,000,000 gallons, or about 2½ times as great as the natural flow. In December, 1895, it was said that the 600-ft. wells are not used except for washing the filters, the water not containing so much iron as to prevent such a use.

The 1,100-ft. well discharges into a wooden tank through a wooden trough perhaps 50 ft. in length, and the 1,000-ft. well directly through an iron pipe, but also at the top of the tank. From this tank the water passes through a short flume to a tank at a lower level, thus receiving further exposure to the air. These tanks are each about 16 ft. in diameter and 6 ft. deep. These tanks were put in as temporary affairs pending the construction of a receiving reservoir. A tank of similar size receives the yield of the 600-ft. wells. The water from the deep wells is said to contain sulphuretted hydrogen gas, so that aeration is desirable to remove this.

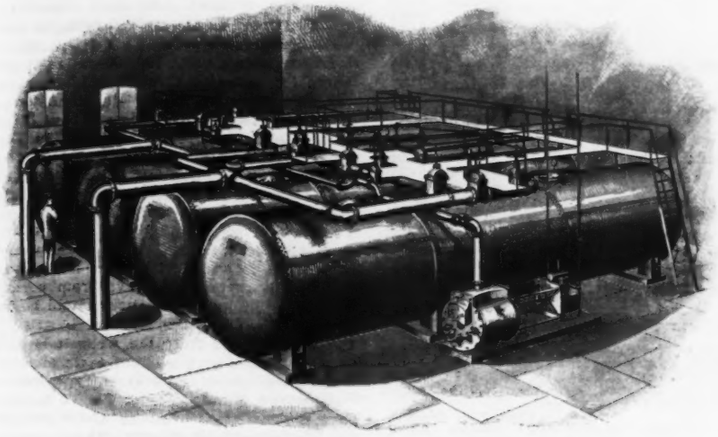
The compressor for the air lift pumps is duplex, 6×22 ins. It is run at 100 lbs. when starting the well, and at a minimum pressure of 87 lbs. thereafter. Steam for the compressor is furnished by a 100-HP. boiler, made by the Abendroth & Root Manufacturing Co., of New York city.

As the water discharges from the deep wells

it looks clear, but in the first tank it was brownish, and in the second had taken on a reddish brown color, while on the flume between the two tanks there was a deposit resembling mineral paint.

The air is kept on the wells until 11 p. m., from which time until morning all pumping ceases, except that the main pumps are started up a few times to prevent the overflow of the tanks from the natural flow of the wells.

Direct pumping is employed, the surplus above consumption going to a 12×125-ft. stand-pipe, not roofed over, giving a capacity of about 106,000 gallons. The stand-pipe is generally kept full, it being the aim to do so continually. There are two 750,000-gallon Gaskill pumps.



VIEW OF CONTINENTAL FILTER PLANT AT ASBURY PARK, N. J.

The filters are located in a temporary wooden addition to the pumping station. The average working head of the filters is 54½ lbs., and their resistence is given as from 3 to 5 lbs. The filtering material in the first of each pair of filters is quartz or sand, and in the second it is animal charcoal. From January to December, 1895, it had not been necessary to renew any of the filtering material, and the filter company states that it had not been renewed up to June 1, 1896. The depth of material is about 4 ft. Each tank is 6 ft. in diameter, and 28 ft. long, made from ⅜-in. steel plates, double riveted.

Regarding frequency of washing, it was stated at the pumping station that this was being done once in 24 hours in December, but in summer, once in 12 hours had been the rule. Air is used with the reverse current in washing, the attendant stating that so far as he had observed, the only advantage of the air is to lessen the time of washing. The air compressor is 18×24 ins., low pressure. Water from the 600-ft. well is used for washing. This is employed in its unfiltered state for the first tank, but this tank being cleaned, filtered water from it, after wasting for a while, is employed for washing the animal charcoal in the second tank.

The writer visited the filter plant on Dec. 5, 1895, and saw it in full operation. On inquiring how much water was required for washing, he was informed that the amount was 30,000 gallons an hour, but further inquiry showed this to be the estimate of the makers. The writer was also told that three hours was taken to wash both sets of filters, 1½ hours for each, when done in the daytime, and four at night, owing to the greater leisure.

Observations during washing showed that a total of about 1¼ hours was consumed in washing one set of filters, but the pumpage at that time was said to be as low as 250,000 to 275,000 gallons a day. About 45 minutes were taken in washing the first filter of the set. At first the wash water was highly colored with iron and after that it graded down until it finally ran pretty clear. When this result was reached the current was turned back to the normal and the filtrate was first wasted a few minutes, then turned into the second filter. The wash water from this tank was first cloudy, with scarcely any reddish, but perhaps a light amber or straw-colored tinge. The quantity of water actually used in washing, according to the pump register, was 17,368 gallons for the sand, and 11,176 for the charcoal filter, making a total of 28,544 gallons. This would indicate about 10% of the total pumpage used for washing, but doubtless with higher rates of consumption the percentages would not increase proportionately. As the water was pumped from the 600-ft. well and wasted, the stand-pipe pressure being off the filters, the lift is very small, probably seldom more than 10 ft.

The pumpage from March to October, 1895, both the total and average daily for each month, and the level at which water was maintained in the stand-pipe (full height, 125 ft.), was as follows:

	Pumpage, gallons, Total.	Av. daily.	Height w't'r in stand-pipe, ft.
March	12,589,000	406,000	90
April	12,337,000	408,000	87½
May	10,081,000	306,000	87½
June	19,367,000*	646,000	105
July	21,332,000	688,000	95
August	29,529,000	953,000	92½
September	17,164,000	572,000	92½
October	12,273,000	396,000	87½

*Including amounts used in experiments.

The consumption indicated above includes the water pumped from the 600-ft. wells for washing the filters.

The cost of the filters and foundations was $20,000. This does not include the temporary wooden building which is to be replaced by a one-story brick structure about 45 ft. sq. at an estimated cost of $1,500.

We are indebted to Mr. Geo. H. Coffin, Superintendent of the water-works, for courtesies shown our representative while at Asbury Park, and to Mr. E. H. Howland, Engineer of the pumping station, for information there obtained.

Just what the Asbury Park plant is capable of doing, the relative value of the sand and animal charcoal filters and the part played by the air in removing the iron is set forth in the following report by Dr. T. M. Drown, President of Lehigh University, who made an exhaustive series of experiments to determine these points in 1895:

To the Water Commissioners of Asbury Park, N. J.

Gentlemen: In accordance with your request I have made a thorough investigation of the character of all the wells which furnish your water supply at Asbury Park, in order to determine the best method of securing from them a water practically free from iron, and satisfactory for all domestic uses.

In my report of Nov. 23, 1893, to the joint commission on water supply of Asbury Park and Ocean Grove, I expressed the opinion that the water of the deep wells, which you have not been able to use on account of the large amount of iron they contained, could be treated by aeration and filtration, and a perfectly satisfactory water supply obtained from them.

My recent investigation confirms this opinion, the water now being supplied to consumers from deep wells containing, on the average, less than 0.0200 parts of iron per 100,000.

For three weeks, from May 17 to June 7, my assistant, Mr. Robert Spurr Weston, has made, under my direction, at the pumping station in Asbury Park, a very large number of examinations of the waters of all the wells, and of the water after it has passed the filters. These examinations were made under all possible conditions, and at all hours of the day and night, to determine definitely a mode of procedure which would ensure uniformly good water at all times.

In the water as it comes from the wells the iron is mainly in the form of sulphate of the protoxide. The water has also a somewhat disagreeable odor from gaseous carburetted hydrogen dissolved in it. On exposure to the air this gas escapes in a comparatively short time and the iron becomes oxidized, forming first a scum on the surface, which resembles oil in appearance, and finally settles out as a rusty precipitate of hydrated sesquioxide of iron. Under ordinary conditions of exposure to the air the complete conversion of the iron to the insoluble form of sesquioxide may require several days, but when the water fully charged with air, as is the case when it is raised from the well by the Pohle air lift pump, is forced through a bed of sand, the friction of the water hastens the oxidation, and the greater part of the iron remains behind in the sand as solid hydrated sesquioxide.

Unless, however, the water contains sufficient air in solution before it enters the filter to oxidize the iron completely, some of the iron will pass through unchanged. The filter itself has no power to remove iron until it has separated out in the solid form as sesquioxide.

The present practice at Asbury Park is entirely satisfactory; namely, raising the water from the two wells—1,040 and 1,100 ft. deep—by the air lift, allowing the water to run into a large tank, with overflow into a second tank, from which it is forced into the filters at the rate of about a million gallons daily. The filters are cleansed by reversed current with water from the 600-ft. wells every 12 hours (this was in the summer when the pumpage was high.—Ed.), and the red hydrated sesquioxide of iron washed out. A simple calculation from the amounts of iron in the well water and in the filtered water shows that about 117 lbs. of metallic iron are removed daily from 1,000,000 gallons of water.

In the Continental filter at use in your works there are two cylinders; the first contains sand and the second bone charcoal, and the water is forced through both cylinders before it passes to the mains. A long series of experiments show that nearly all the iron is removed in the first or sand filter, and that very little remains to be done by the second or bone charcoal filter. In some of our experiments it was found that iron was actually added to the water by the bone charcoal filter. This was, however, due to the fact that the filter had not been thoroughly cleaned. In actual working, at present, the bone charcoal filter removes only an insignificant amount of iron, since the first, or sand filter, removes 98% of all the iron in the water.

I give in Table I. some of the results of the analyses made of the original well waters and filtered water during the period—May 17 to June 7—by Mr. Weston at the pumping station at Asbury Park:

TABLE I.—Determinations of Metallic Iron in Artesian Wells at Asbury Park, May 18 to 21, 1895.

(Parts per 100,000.)

	No. 1.	No. 2.	No. 3.	Nos. 4 to 8.	No. A. P.	Auxiliary.
Depth of wells, ft.	1,040	1,100	1,000	600	400	600
May 18	2.300	2.600	2.600	0.190	....	...
	2.125	3.300	3.400	0.157	...	...
	1.600	3.200	...	...	...	...
	1.330	1.310	1.520	0.137	...	...
	1.500	1.900	...	...	0.069	0.157
May 20	1.260	1.950	1.550	0.175	...	...
	1.130	1.800	1.272	0.180	...	...
	1.400	1.820	1.570	0.180	...	...
	1.400	1.900	...	...	...	...
	1.400	1.640	...	...	...	...
	1.440	1.900	...	...	...	...
May 21	1.130	1.400	...	0.155	...	...
	1.190	1.360	...	0.165	...	...
	1.260	1.320	...	0.240	...	...
	1.070	1.330	...	0.205	...	...
	1.110	1.340	...	0.227	...	...
	1.170	1.460	...	0.125	...	...
	1.130	1.370	...	0.190	...	...
	1.080	1.460	...	...	...	...
	1.070	1.360	...	...	...	...

From Table I. it will be noticed that the amount in wells Nos. 1 and 2 decreased on continuous use until the third day, when it became reasonably constant. The average of nine determinations on May 21, is, for well No. 1, 1.125, and for well No. 2, 1.378 parts per 100,000, equivalent to 0.66 and 0.80 grains per gallon, respectively. Well No. 2, which is not in use at present, would probably contain, on continuous pumping, about the same amount of iron as well No. 1.

The 600-ft. wells contain very much less iron in solution, the average of the above 13 determinations being 0.1791 parts per 100,000. This amount, however, unfits water for general domestic use. Although this water does not taste of iron, as is the case with the water of the deep wells, yet the iron separates out in the course of time, forming a reddish coating on the vessels containing it. Its use is not to be recommended unless it is previously aerated and passed through the filter.

The 400-ft. wells are entirely satisfactory, but unfortunately the amount of water obtainable at this level is insufficient for the supply of the borough.

In Table II. I give a summary of some of the determinations of iron in the filtered water during the period from May 18 to June 7:

TABLE II.—Determinations of Metallic Iron in Original and Filtered Water When Using the 600-ft. Wells Exclusively, from May 21 to May 28, 1895. Rate about 150 Gallons a Minute.

(Parts per 100,000.)

	Iron in well water.	Iron after passing—Sand filter.	Both filters.
May 21	0.155	0.016	0.045
	0.165	0.011	0.038
	0.240	0.045	0.072
	0.205	0.019	0.052
	0.227	0.012	0.041
	0.125	0.022	0.067
May 22	0.190	0.009	0.033

Balance of figures relate only to iron after passing sand filter.

May 22.—0.017, 0.012, 0.019, 0.026, 0.020, 0.025.
May 23.—0.025, 0.023, 0.026, 0.028, 0.037, 0.034.
May 24.—0.023, 0.015, 0.022, 0.023.
May 28.—0.025, 0.029.

It is not to be inferred from Table II. of results, that the increase of iron on passing the bone charcoal is a necessary condition of operation of the filter. The bone charcoal in this case had probably become charged some weeks previously with iron from the water of the deep wells, which had not been properly aerated, and gave up this iron to the purer water subsequently passing through it.

The fact is an interesting one, and serves to emphasize

the necessity of thorough aeration of the water before it is allowed to enter the filters.

An average of the results in Table II. show that 87.9% of the iron was removed by the sand filter. In this series of experiments, the water was pumped directly from the wells. In a subsequent series of experiments with the 600-ft. wells, the water was aerated by the air lift, and the percentage of removal of iron by the sand alone was 92.7%, and by both filters, 95%.

Table III. gives the results of treating wells No. 1 and 2 by the sand filter only. The water had stood in tanks for some time, and some of the iron had already settled out.

TABLE III.—Determinations of Metallic Iron in Water of Deep Wells, Filtered Through Sand Only, on May 28, 9 a. m. to 11 p. m. Rate about 200 Gallons per Minute.

(Parts per 100,000.)

Iron in deep wells.	Iron after passing sand filter.
1.095	0.025, 0.027, 0.023, 0.027, 0.029, 0.041, 0.045, 0.043, 0.042, 0.040, 0.039, 0.042, 0.038.
1.000	0.025, 0.024, 0.024, 0.027, 0.029, 0.030, 0.031, 0.033, 0.034.

The average amount of iron shown as removed in Table III. was 96.9%. In Table IV. the result of treating the water of both deep wells by both filters is given.

TABLE IV.—Determinations of Metallic Iron on Filtering Water of Both Deep Wells Through Both Filters. Rate, 200 Gallons a minute.

(Parts per 100,000.)

Date.	Iron in well waters.	Iron after passing—Sand filter.	Iron after passing—Both filters.
May 29, 4 to 9 p. m.	0.945	0.075	0.011
		0.057	0.009
		0.053	Trace.
		0.042	0.019
		0.042	0.021
		0.042	0.019
		0.062	0.019
May 30, 4 to 10 p. m.	0.810	0.036	0.039
		0.033	0.030
		0.034	0.027
		0.015	0.000
		0.018	0.016
		0.023	0.018
		0.035	0.022
		0.033	0.026
		0.037	0.032
		0.072	0.024
		0.036	0.024

In the interval between 9.30 p. m. May 29 (Table IV.), and 1 p. m. May 30, the filters were thoroughly washed with water from the 600-ft. wells and the filtering of the deep well water resumed at 4 p. m., May 30.

The amount of iron in the water treated is seen (Table IV.) to be much less than the original well water; this is owing to the settling out of some of the iron on oxidation in the collecting tanks.

Averaging all the results in Table IV. we find the removal of iron by the sand filter to be 95.54%, and by both filters 98%.

In the series of the deep wells, the results of which are given in Tables III. and IV., the water was taken from the open collecting tanks supplied by the natural flow of these wells. It had stood sufficiently long in the tanks to become thoroughly saturated with air before it was pumped into the filter. In the experiments shown in Table V. the water was raised from the wells by the air lift and was thoroughly aerated when it flowed into the tanks. This quick aeration is necessary when the pumps are working at full speed, owing to the small size of the collecting tanks.

Table V. gives the results of experiments on the deep wells when the water was raised by the air lift and filtered at different rates.

During this time, May 30 to June 4, the filters were run night and day, with an intermission of about an hour or an hour and a half every 12 hours, for washing out the iron oxide which had collected in the filters in this time.

The average removal of iron for the six days, assuming that the water from wells Nos. 1 and 2 was used in equal proportions, and that its average contents of iron, as it flowed into the tanks, was 1.1319 parts per 100,000, was, for the sand filter 97.70%, and for both filters, 98.23%, or only 0.53% additional removal by the charcoal filter. If we take the last two days only, when the pumps were working at their maximum rate, the removal of iron by the sand filter was 98.30%, and by both filters, 98.51%, or only 0.21% additional removal by the charcoal filter.

TABLE V.—Determinations of Metallic Iron in Filtered Waters of Deep Wells Through Both Filters at Different Rates.

(Parts per 100,000.)

Date.	Rate per minute, gallons.	Iron remaining after passing—Sand filter.	Iron remaining after passing—Both filters.
May 30, 9 to 11 a. m.	200	0.038	0.034
		0.035	0.024
		0.039	0.033
May 31, 3 to 10 p. m.	484	0.021	0.018
		0.017	0.015
		0.024	0.006
		0.038	0.008
		0.038	0.022
		0.038	0.017
		0.032	0.024
		0.033	0.015
		0.027	0.010
June 1, 9 a.m. to 9.30 p.m.	415	0.031	0.019
		0.025	0.028
		0.023	0.011
		0.031	0.019
		0.050	0.015
		0.022	0.011
		0.026	0.010
June 2, 12.30a.m.to 5.30p.m.	415	0.024	0.033
		0.029	0.023
		0.016	0.015
		0.018	0.020
		0.030	0.070
		0.018	0.017
		0.016	0.020
June 3, 12.15 p.m. to 9p.m.	700	0.017	0.013
		0.018	0.013
		0.018	0.018
June 4, 11 to 12.20 a. m.	...	0.023	0.014
		0.020	0.026

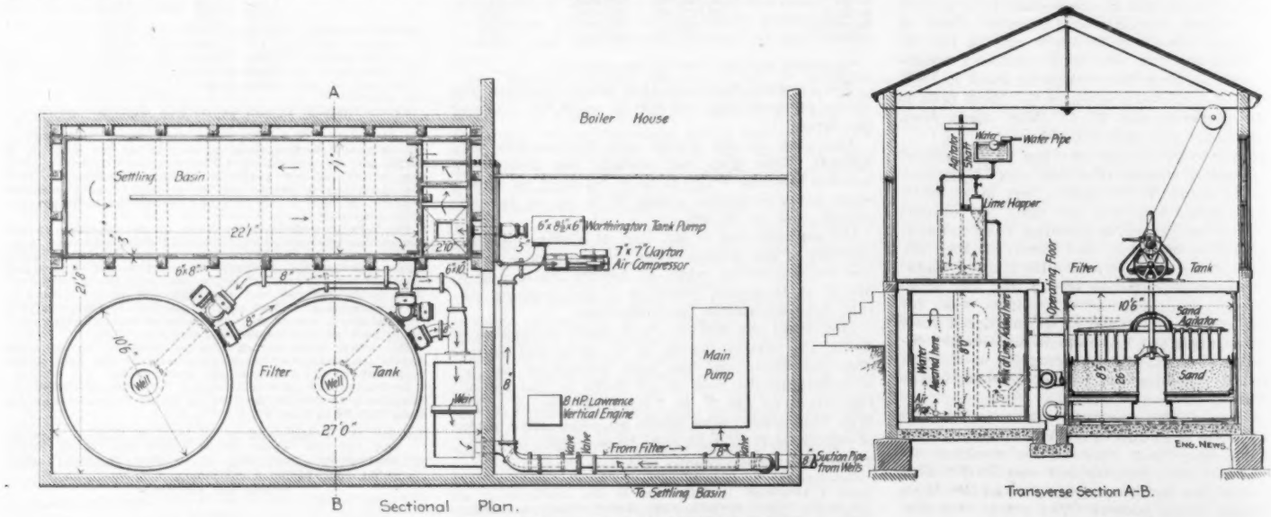
The quality of the water now supplied to consumers in Asbury Park, is in every respect satisfactory for drinking and general domestic use, and the continued favorable action of the filter in removing the iron from the aerated water is confidently to be expected.

Thomas M. Drown.

Massachusetts Institute of Technology, Boston, July 3, 1895.

The following comments on the above report, have been furnished us by the filter company:

The use of open collecting tanks, or of air lift pumps, or of any other system of aerating the water is not essential to the efficiency of the filters in removing the iron from the water at Asbury Park. These filters were completed, put in operation, thoroughly tested and accepted by the Water Commissioners of the Borough on the chemist's certificate that they complied with the very stringent contract requirements, before the collecting tanks and the air lift pumps were put in. The latter were put in solely for the purpose of increasing the volume of water obtainable from the wells. At Atlantic Highlands, and at other places where Continental filters are in use on water of the same character, no method of aerating the water before filtration is used, and the filters are equally efficient in removing the iron, the water being passed directly from the wells into the filters and thence into the mains. Further, the company maintains that the second bed is an essential part of its filters. At certain seasons of the year, the greater part of the work of removing the iron will be done by the first bed, but at other seasons of the year, the first bed is inefficient, and the use of the second bed is essential to the thorough removal of the iron. The company has satisfied itself of this by close examination and extensive experiments, extending over all seasons of the year.



WARREN FILTER PLANT AT KEYPORT, N. J.

The Warren Filters at Keyport.

The problem of removing iron from artesian water has been approached at Keyport in a different manner than at Asbury Park and Atlantic Highlands, although mechanical filtration is common to all three plants. At Keyport filtration is preceded by a combined chemical treatment and aeration, effected in a settling tank, lime being the chemical employed. Before describing the process employed it will be well to give some information regarding the locality and the source of water supply.

Keyport is a town on Raritan Bay, which in 1880 had a population of 3,411. Water-works were put in operation by the town in August, 1893. The supply is drawn from six artesian wells, located on the shore of the bay, at about high water mark, and 150 ft. apart. The wells are from 225 to 240 ft. deep, with casings 4½ ins. inside diameter. The original individual capacity of the wells is stated as about 60 gallons per min.

Each well is connected by a 4½-in. pipe with an 8-in. suction main. A 700,000-gallon Worthington pump forces water through a 12-in. main about one mile long to a 20×125-ft. stand-pipe, having an open top and a capacity of about 300,000 gallons. The consumption is small. In December, 1895, when the writer visited the plant, the pumps were being run only a few hours every other day.

The purification plant was not put in until 1895, having been started in September of that year. Previous to its introduction much trouble was caused by iron in the water. This would settle in the mains and at times would be very pronounced in the water drawn from certain taps, while others in near-by houses would be free from it. The iron is in the form of bicarbonate. As the water comes from the wells it is said to be perfectly clear, with a slight taste of iron.

The filters are of the Warren type, made by the Cumberland Manufacturing Co., of Boston. They have a guaranteed capacity of 500,000 gallons a day, and operate by gravity. There are two open, wooden tanks, each 10½ ft. in diameter and 8 ft. deep, having 26 ins. of filtering material, consisting of coarse sand and fine gravel. The filters are washed twice a day, when in use. This is effected by reversing the current and by using the revolving arms with their rake-like teeth, shown by the accompanying illustrations. These arms are rotated by power and gradually sink into the sand as they revolve. They are designed to loosen the sand and gravel, which becomes packed, and thus to lessen the work of the wash water and the quantity required. Filtered water is used in washing. When the filters had been in operation only some two months it was stated that 15% of the water pumped was required for washing, but that the contractor had promised to reduce this.

Regarding the amount of wash water, Mr. Nye, of the company that put in the filters, wrote us under date of June 1, to the following effect: It is customary to give the amounts of wash water in percentages of the amounts of water filtered, instead of the amount pumped. To arrive at 15% Mr. Nye thinks that the water drained from the filter preparatory to washing was included. The plant has been changed, recently, so the upper

4 ft. of the water drained from the filter preparatory to washing is saved.

Lime and aeration is employed in connection with a settling tank, the details of this part of the plant and process being described below. About 4 lbs. of lime are used to each 12,000 gallons of water filtered, or 330 lbs. per 1,000,000 gallons. The lime is bought from Tomkins Bros., 74 Passaic St., Newark, for about $1.00 per bbl., f. o. b. at Newark. Freight is about 10 cts. per bbl., and haulage very light, as the haul is short.

The cost of the filters, settling basin, extra pump and air compressor was $3,700; of the 22×25-ft. brick addition to the pumping station, $771; and of extras ,about $330; making a total cost of about $4,700.

The above information, except as noted, was obtained from Mr. Rufus Ogden, Water Commissioner, by correspondence and during a visit to the plant in December, 1895, supplemented by a communication dated May 30.

Various analyses of the amount of iron in the water before filtration place it at from 0.5 to 3.2 parts per 100,000. Analyses of the water before and after filtration, made just after starting the plant, furnished by Mr. W. B. Nye, Manager of the Cumberland Manufacturing Co., are as follows:

(Parts per 100,000.)

	Filtration— Before.	After.
Total solids	17.2800	9.7500
Organic and volatile	22.2800	2.5500
Chlorine	0.7080	0.7080
Free ammonia	0.0052	0.0013
Albuminoid ammonia	0.0050	0.0020
Iron (Fe.)	2.0000	0.0500
Sulphuric acid	1.7000	0.8500

These figures show 97½% of iron removed. The other ingredients are unimportant, unless it be the sulphuric acid, which was reduced 50%. The total solids were reduced about 43%, and the "organic and volatile" matter, 88%.

The following detailed description of the accessories to the filter proper was furnished for use here by Mr. Nye:

The filters run but a few hours a day, owing to the small requirements of the town, and as the supply of water seems to be somewhat limited, we are on the point of making one or two slight alterations to facilitate washing, as there is hardly water enough for one filter to wash the other in the usual manner. By means of a by-pass, we tap the suction pipe from the wells before reaching the pump, and with a 6 × 8½ × 6-in. Worthington tank pump, pump the water, together with considerable air, to the settling basin, which forms a part of the filter plant. The end of the settling basin next the pump is partitioned off, and the water from the pump enters a portion of the settling basin 3 ft. × 2 ft. 10 ins., having a hopper-shaped bottom. From this it passes over a partition and down a passageway 2 ft. 10 ins. × 1 ft., and thence through a propeller into a third section of the tank 2 ft. 7 ins. × 2 ft. 10 ins., from which it passes over a partition into the settling basin. Here it drifts along, passing down one side of a long center partition, as shown by the illustration, and up the other side, where it enters a pipe leading to the filters. Above the settling basin is placed a cylindrical tank 3 ft. in diameter and 4 ft. deep, in which the solution of lime is prepared. In the cover of this tank is placed a galvanized iron hopper with a perforated bottom, and in this hopper is placed fresh lime, broken up into small fragments. The water supply pipe is branched above the lime tank and a portion of it is delivered over this hopper full of lime by means of finely perforated pipes, so that there is a constant spray of water upon the lime, which thereby ensures a continuous slaking, the water and the lime passing down through the hopper and into the large tank, where it meets a further supply of water, and by the constant rotation of a paddle having wooden blades, so arranged as to keep a constant upward circulation, a milk of lime of the proper consistency is made, which passes off through an overflow pipe by which the milk of lime is delivered into the hopper through which the water enters the settling basin. By delivering the lime in this manner it is sure to meet every portion of the incoming water, and such lime as is not at once reacted upon by the water, remains in the hopper and is constantly agitated, so that all the lime is eventually brought into solution. The water and the lime then continues its course, as previously described, and on its entrance into the third section through the propeller, meets a supply of air furnished by a 7 × 7-in. Clayton low-duty air compressor.

It is evident that by the addition of the lime to the water, the iron which has existed in the shape of a bicarbonate, is converted into a carbonate, which by the further aeration is converted into a sesquioxide, which combining with the water forms into a ferric hydrate, while any excess of lime that may exist is also oxidized, and thus prevented from separating out later, as it would on exposure to the carbonic acid in the air. The course of the oxidation can be plainly seen, as the water entering the basin is clear, after receiving the lime it turns green, and after aeration passes from green through yellow into red, due to the presence of hydrate in the water. Much of this hydrate and the lime settles to the bottom of the settling basin during the progress of the water from the point of delivery to the filters, and the minute portions of hydrated iron are caught in the filters, from which the water issues bright, clear, sparkling, free from iron and much softer than before treatment. I enclose copy of analysis of the water both before and after treatment, from which you can see the results obtained. When the plant was first placed in operation, the water for the lime apparatus was supplied by one of our well-known alum pumps, but we found the rate of pumping to be so uniform that a propeller was unnecessary, and the supply of water once regulated by the valves will take care of itself, and by placing from 7 to 8 lbs. of lime in the hopper per hour, perfect results are obtained.

WEATHER TABLE FOR APRIL, 1896. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.) Average.	Max.	Min.	Range.	Wind. Velocity in miles per hour. Average.	Max.	Direction at time of max. velocity.	Precipitation—rain or melted snow—inches. Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	42.1	81	14	67	8.4	32	NW	0.51	0.27	8
	Portland, Me.	43.4	77	24	53	7.7	30	NW	1.65	0.84	9
	New York City	50.4	90	23	67	13.3	52	NW	1 24	0.40	6
	Pittsburg, Pa.	57.2	90	22	68	6.6	21	W	3.39	1.27	11
	Chicago, Ill.	53.4	84	18	66	19.8	60	S	2 79	1.18	11
	Omaha, Neb.	56.8	89	20	69	10.5	40	NE	1.28	1.81	15
	St. Paul, Minn.	47.4	80	13	67	9.0	37	SE	5.63	0.91	18
	Duluth, Minn.	38.1	60	11	49	11.3	52	NW	4.06	0 91	15
	Bismarck, N. Dak.	42 2	79	18	61	13 2	43	NW	2 23	1.22	8
	Average	47.9	81	18	63	11.1	41		2.86	0.98	11
Southern Cities.	Washington, D. C.	56.6	93	28	65	7.6	36	NW	1.07	0.51	9
	Louisville, Ky.	64.6	90	30	60	9 9	39	W	0 25	0.12	6
	St. Louis, Mo.	64.8	88	30	58	14 1	39	NW	2.43	1.45	8
	Savannah, Ga	68.6	90	42	48	9.3	36	NW	1.51	1.30	5
	Kansas City, Mo.	61.4	87	25	62	11 6	36	SW	3.21	1 30	11
	Jacksonville, Fla	70 0	92	43	49	6 6	25	NE	0.49	0.38	2
	Chattanooga, Tenn.	65 0	90	38	52	7.6	37	NW	3.31	1.12	11
	New Orleans, La.	70 6	84	49	35	8.8	36	SE	4 81	2.25	5
	Memphis, Tenn.	69 0	87	39	48	10.5	44	SE	3.78	1.78	5
	Palestine, Tex.	68.3	85	38	47	8.9	34	SE	1.22	0.88	7
	Average	65.9	89	36	53	9.5	36		2 21	1.11	7
Western Cities.	Helena, Mont	39.4	64	6	58	7.4	36	SW	1.23	0.64	5
	Port Angeles, Wash.	43 8	59	28	31	6 1	34	W	1.01	0.24	17
	San Francisco, Cal.	51.6	66	41	25	11.6	36	W	5.16	2.43	15
	Salt Lake City, Utah.	46.4	74	18	56	7.9	37	W	2.53	1.06	11
	Santa Fe, N. Mex.	47.8	70	13	57	9 4	50	SW	1.11	1.08	2
	Denver, Colo.	49 6	80	9	71	9.6	55	NW	0.93	0.41	6
	Yuma, Ariz	65.8	91	41	50	9 2	37	W	T	T	0
	Average	49.2	72	22	50	8.7	41		1.71	0.84	8

The power for cleaning the filters, operating the lime agitator and the air compressor, is furnished by an 8-HP. vertical engine made by the Lawrence Machine Co., of Lawrence, Mass., builders of the well-known centrifugal pump which bears their name.

NOTES AT THE ELECTRICAL EXPOSITION.

The Electrical Exposition which has been held in New York city during the month just closed was a success not only financially but in point of the interest it aroused among both scientific men and the laity. Coming at a time when the whole country is stirred by the recent discoveries in electricity, it has drawn crowds of visitors. In size, it did not compare, of course, with the display in the Electricity Building at Chicago in 1893; but there have been exhibited many of the modern applications of electricity, and through the generosity of scientific men in New York and vicinity the public has been permitted to see the workings of the most recent inventions. Mr. D. McFarland Moore fitted a room with his vacuum tubes and invited the public to see "artificial daylight." Mr. Thomas A. Edison personally supervised the installation of his fluoroscope whereby one might enjoy the novel sensation of looking at his own bones. Next to these exhibits the model of the Niagara power plant has attracted most attention from visitors. It includes a section of the plant of the Niagara Power Co., showing the tunnel, penstock, shafts, etc. The power for operating this model was transmitted from the Falls, over the wires of the Western Union Telegraph Co., a distance of 465 miles. Telephone receivers in connection with Niagara gave an opportunity to listen to the roar of the Falls. A practical electrical laboratory, fitted with modern apparatus, and under the direction of Prof. Max Osterberg, of Columbia University, gave instruction in the methods used in making electrical experiments.

Arc lamp manufacturers were largely in attendance. The arc lamp is one of the least efficient of electrical appliances on the market, the difficulties to be met being shown by the claims of the various manufacturers to be among others the perfect alinement of carbons, lack of delicate controlling apparatus, reduction in energy consumed in controlling device, and noiseless arcs.

The generating plant in the basement included a modern boiler outfit which supplied all the steam used, and was as nearly automatic as possible. The water was kept at even level by an electric pump; a coal conveyor brought the coal and deposited it in the mouth of automatic stokers and a second conveyor removed the ashes (Eng. News, April 30).

Electric power was furnished by a variety of direct connected dynamos; although a dozen or more were constantly running there was a freedom from noise which contrasted remarkably with the terrific rear of the old-time dynamo room. To demonstrate its freedom from vibration, one of the engines exhibited was connected direct to an Eddy generator and supported only by three iron pins placed under the front corners and rear of the bed plate and with no bolts to secure it to the foundation. There was no device to hold the bed plate from slipping off these pins, and it was steadied only by the exhaust pipe which passed down through a cement floor.

Considerable space was occupied by an exhibit of historical interest showing the development in the application of electricity from its infancy; this exhibit contained many of the earliest inventions of Elihu Thompson and Thomas A. Edison; one of the first phonographs built by Mr. Edison carried the tin foil cylinder on an inch shaft, to which were attached two fly wheels nearly a foot in diameter.

The lack of exhibits of electric railway apparatus was apparent; with one or two exceptions this branch of the electric industry was wholly unrepresented.

Conduit and wire manufacturers were present in abundance. Almost every form of insulation known was represented; as yet, however, no manufacturer is able to claim immunity from electrolysis, the great bugbear of underground work in cities with electric railways.

The new system of operating boats on the Erie Canal showed a motor traveling on a large overhead steel cable by means of grooved pulleys, driven by the motor. The motor hangs from the pulleys and receives its current from the upper cable, while the return circuit travels through another and smaller cable running under and parallel to the large cable. From the motor frame a rope leads to the canal boat; the friction of the grooved pulleys is sufficient to draw the boat (Eng. News, Aug. 1 and Oct. 31, 1895).

Novelties in electrical apparatus were shown in various cooking utensils, electric flat irons, illuminated clocks, lamp lighters and advertising signs.

A striking feature of the exposition was the large number of independent exhibitors. It has seemed at times within the past few years that almost the entire electrical business would come into the hands of one or two great corporations. The exposition shows that many smaller companies are actively at work relying on the factors of personal supervision by the owner and merit in the goods produced to secure them a share of the business.

A PORTABLE RAILWAY to haul road making material from the railway to the roads now being built by the county commissioners in Chatham county, Georgia, is proposed, on account of the slowness and expense of the present method of hauling by horses.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Published every Thursday at Tribune Building, New York. Entered at the Post Office, New York, as Second Class Matter.

D. McN. STAUFFER, CHARLES WHITING BAKER.....EDITORS.
WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, A. B. GILBERT.....ASSOCIATE EDITORS.
CHAS. W. REINHARDT.....CHIEF DRAFTSMAN.

GEO. H. FROST, F. P. BURT.....BUSINESS MANAGERS.
ALFRED E. KORNFELD, New York..... ADVERTISING
F. A. PECKHAM, Chicago..... REPRESENTATIVES.

PUBLICATION OFFICE.....Tribune Building, New York.
CHICAGO OFFICE.....1636 The Monadnock.
LONDON AGENCIES: KEGAN PAUL, TRENCH, TRUEBNER & Co. (Limited), Paternoster House, Charing Cross Road; SAMPSON LOW, MARSTON & Co., (Limited), St. Dunstan's House, Fetter Lane.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00; Single copies, 15 cents. To all other countries in the Postal Union, add $2.08 per annum (4 cents per number) to above prices for postage. No club rates allowed. Mailing addresses may be changed at will by sending both old and new address. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 326 means that subscription is paid to the 32d week (that is the issue of Aug 6) of the year 1896; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes to standing advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The President's veto of the River and Harbor bill appears to have been generally expected, but the approval or disapproval of his act which has been expressed is drawn wholly on political lines, and he would be a wise man, indeed, who would say whether veto or approval should have been given, viewing the question from the broad standpoint of the public interest. Of course no intelligent man doubts that, taking it as a whole, the River and Harbor work yields benefits fully proportioned to its cost, but, on the other hand, it is well known that not the public interest but an equal division of the spoils is the guiding principle in making up the River and Harbor appropriations, and the effect of this is at times to award niggardly appropriations to works which deserve more liberal treatment, and to cause lavish expenditures on other enterprises, where no adequate returns can ever be made in the way of public benefit. How to practically remedy this is a problem for which we have heard no solution, and the President's veto message presented none. The entire failure of the river and harbor appropriations in this congress would probably be a much worse injury to the public than the extravagance and expenditure on unworthy projects which may be involved in the 417 items of this bill.

However, there appears at this writing to be little prospect that the bill will fail of final passage, as the House, on June 2, overruled the veto message by a vote of 220 to 60, and the Senate will probably have also given its approval by the time this reaches our readers.

Scientific investigations of the operation of the steam engine (and especially of the locomotive) under actual working conditions, have disproved some of the theoretical and assumed principles which have generally been accepted as established facts. The latest case to which this statement applies is the form of the exhaust jet in locomotives, and its effect upon the draft and the fire in the firebox. In nearly every treatise and discussion on the locomotive in which this matter is included, it is assumed and stated as an established fact that the jet of steam from the exhaust nozzle expands like an inverted cone until it fills the whole diameter of the smokestack, and on account of its intermittent action acts as a piston, tending to create a vacuum in the smokebox, and thus causing a draft through the tubes and firebox. This view of the case has been almost universally accepted by both theoretical and practical men. Actual investigation, however, has recently shown that this is not the case. Some months ago Prof. Goss, of Purdue University, made some experiments on the locomotive mounted in the laboratory of the university, to ascertain the shape of the exhaust jet. His conclusion was that the outline of the jet is bounded by lines which are somewhat curved, and that it is only for a short distance above the nozzle that the expansion or divergence is uniform, while higher up the lines curve toward each other, becoming nearly or quite parallel before entering the smokestack. In another column of this issue we publish an abstract of a paper by Mr. J. F. Deems, Division Master Mechanic of the Chicago, Burlington & Quincy R. R., giving the results of investigations made as to the form of the steam jet in the smokestack of a locomotive in operation. The investigations were made with the engine in both freight and passenger service, and the results were that the jet was found to have practically a uniform diameter from a point about 18 to 24 ins. above the nozzle to within 27 ins. of the top of the stack. In freight service the jet then widens out so as to strike the sides of the smokestack about 8 ins. below its top (which does not give room for any piston or pump action), but in fast passenger service the jet does not reach the sides of the smokestack at all.

If there is no piston action, what causes the draft? This does not seem to be a difficult question. In the first place it must be remembered that in actual service, even at low speeds, the jet is practically a continuous stream of steam from the exhaust nozzle, owing to the comparatively small area of the nozzle and the rapid succession of the four exhausts for each revolution of the driving wheels, the four separate pulsations being almost imperceptible. This fierce jet passing up through the smokestack induces an upward current of air which is fed by the flow through the firebox and tubes. This has been apparently proved by an experiment made by Prof. Goss. He blocked the slide valves of the laboratory engine, and opened the throttle valve until the pressure at the exhaust nozzle was equal to that which exists when the engine is running. The steady flow of steam thus obtained gave as good a draft as that obtained with the engine working in the ordinary way. The sparks and cinders travel with this induced current of air, and probably surround the steam jet before mixing with it. This accounts for the wear or cutting of the smokestack at its throat or "choke." In order to prove whether these conditions exist under varying conditions, Mr. Deems made tests with nozzles at varying lengths and with smokestacks of different diameter, the results being proportionally alike, showing that the results may be considered as of general application.

Recently published accounts of experiments made in 1892-1894, at Hanover, Germany, to ascertain the best form of smokestack and exhaust nozzle, show that it was assumed that the steam should and does fill the smokestack and causes the draft by a piston action, but it does not appear that any tests were made to establish the truth of this assumption. As a matter of fact, it was probably looked upon as axiomatic, thus needing no demonstration, and this has been the almost universal view of the case in all countries. In some of these German tests, bridges were inserted in the exhaust nozzle for the purpose of spreading the jet, and causing it to more quickly "fill" (?) wide and short smokestacks. Nozzles 5⅛ in. diameter at the top and 6 5-16 at the base, 5⅛ ins. high, were said to give a cone jet with an inclination of 1 to 2.4 for a height of about 29 ins. above the nozzle, while the insertion of a bridge gave a cone jet of elliptical section, with an inclination of 1 to 2.45 in the plane of the cone, and 1 to 1.5 and 1 to 1.6 at right angles to it. It was assumed that the pressure of the jet and its influence on the draft varied during each "blow" of steam from the nozzle, but, as already noted, it is hardly possible that this can be appreciable in a locomotive when running, since the pulsations are so rapid, especially when it is considered that in a simple engine there are four "blows" to each revolution. With an engine having driving wheels of 15 ft. circumference and running at 30 miles per hour, this would mean 176 revolutions per minute, giving 704 "blows" of steam from the nozzle, or 11¾ "blows" per second. Since the results of the investigations of Prof. Goss and Mr. Deems controvert merely established opinions based on theoretical assumptions, and do not controvert established facts, there seems little reason to doubt that the conditions which these investigations show are those which normally and generally exist in practice. The most important practical result of this new knowledge of what actually goes on in the smokebox and stack of a locomotive will probably be a tendency towards widening the stacks at the choke. The things to be aimed at by those working to improve locomotive draft appliances are first to get as strong a draft as now with larger exhaust nozzle and less loss by back-pressure, second to get a draft which shall be more evenly distributed over the tubes and so shall require less obstruction in the shape of deflector plates in the smoke-box, and third and most important to get draft appliances in such shape that a variable draft can be used and made successful.

WOULD A RAPID TRANSIT RAILWAY IN NEW YORK CITY PAY?

In our review of the rapid transit situation in New York in our last issue, we were obliged to touch briefly upon many points, and to state many propositions without presenting the facts and figures on which they were based. In the opinion of the Supreme Court judges putting a veto upon the enterprise, it was said in effect that there was no expectation or prospect of direct profit resulting to the city from the operation of the road. It appears to us that this presents a misleading view of the case, and that the fact is not sufficiently appreciated that there is every prospect that the proposed rapid transit railway would not only pay the interest on its cost at the start but would rapidly become an income-earning enterprise, yielding handsome revenue to the city.

We, therefore, take space to print the following letter from a prominent citizen of Brooklyn and our reply thereto:

Sir: I have read your remarks regarding rapid transit, in your last issue, with great interest, and solicit your indulgence to say why your remarks will seem inconclusive to many. The charm of real rapid transit lies in its attraction for long distance riders. It must be self-evident that it cannot attract profitable volume of short distance traffic against improved and improving competition. The real question then is how many passengers can be transported at 50 miles per hour over two tracks. The volume of traffic over the Brooklyn Bridge is less than that seeking to ride northward, and is a fraction of what would be necessary to pay interest on the underground bonds. Will any one undertake to handle the Brooklyn Bridge traffic at 50 miles hourly? Will any one maintain—as no one has yet openly maintained—that the underground route should be built by the city, with a certainty of loss upon traffic in the hope of gain from taxes? If so, will any one maintain that Brooklyn and Staten Island—now part of Greater New York—are properly chargeable with any portion of the risk and cost? Or, if this seems right to New York city, is it reasonable to expect that the changes of law which you indicate can be had against the opposition of what is—or soon will be—the major portion of Greater New York in both area and population? In short, has not the situation and outlook changed, and are there not greater difficulties than those which the commission thinks insuperable? Are you justified in your position that the decision is based on the court's protection of the real estate owners? Are not those really protected, the city bondholders and taxpayers? I write in no contentious spirit, but as one having a high regard for your opinion and desirous of reading your views upon questions here asked. I am Yours very respectfully,

Brooklyn, April 28, 1896. "Great York."

The "self-evident" proposition with which our correspondent opens his letter is to us not self-evident at all. It is true that the greatest gain in rapid transit is to long-distance riders; but we certainly believe that the local tracks of the

GENERAL LIBRARY,
UNIV. OF MICH.
8 JUN 1896

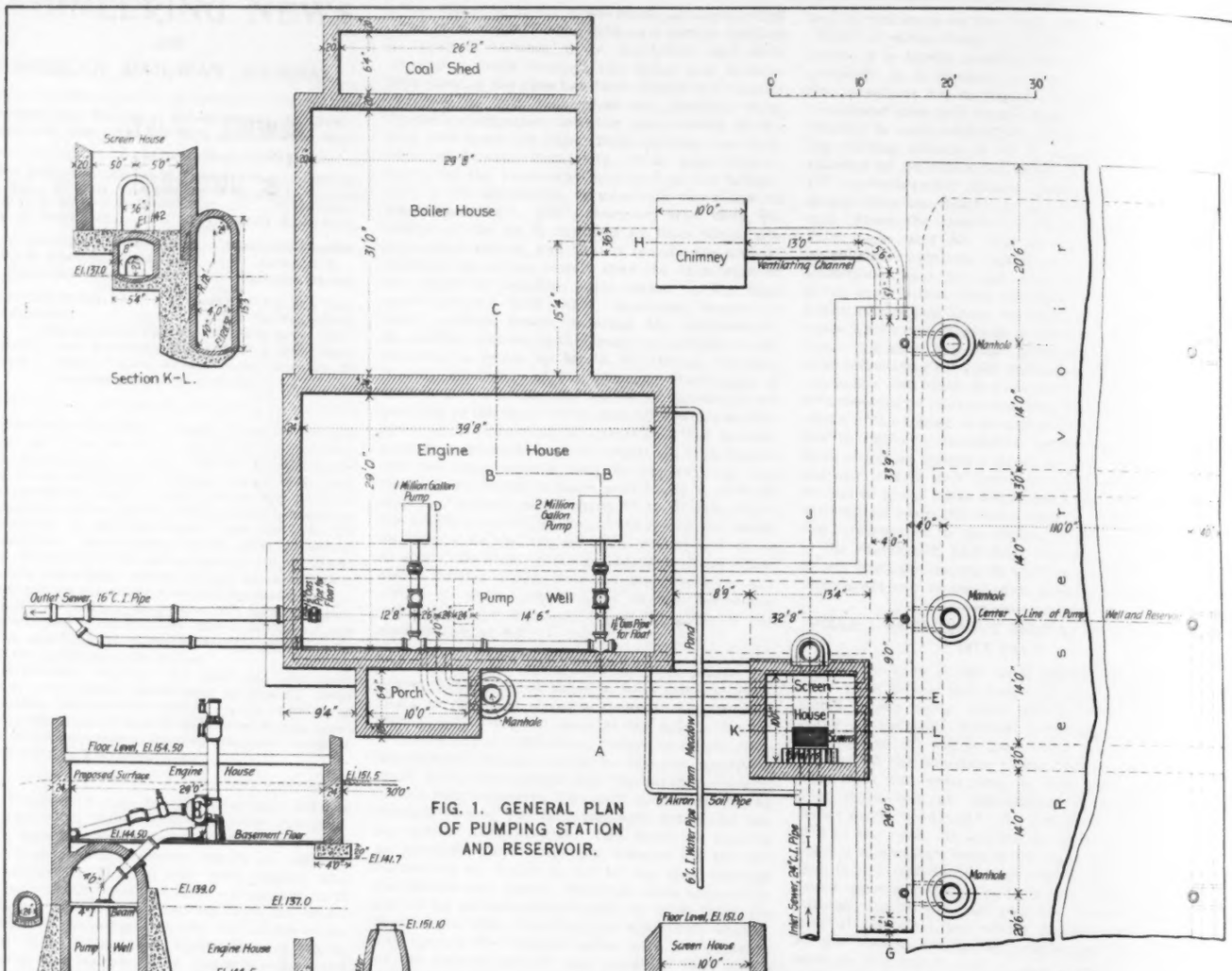


FIG. 1. GENERAL PLAN OF PUMPING STATION AND RESERVOIR.

FIG. 2. SECTIONS THROUGH PUMPING STATION AND ACCESSORIES.

ENG. NEWS.

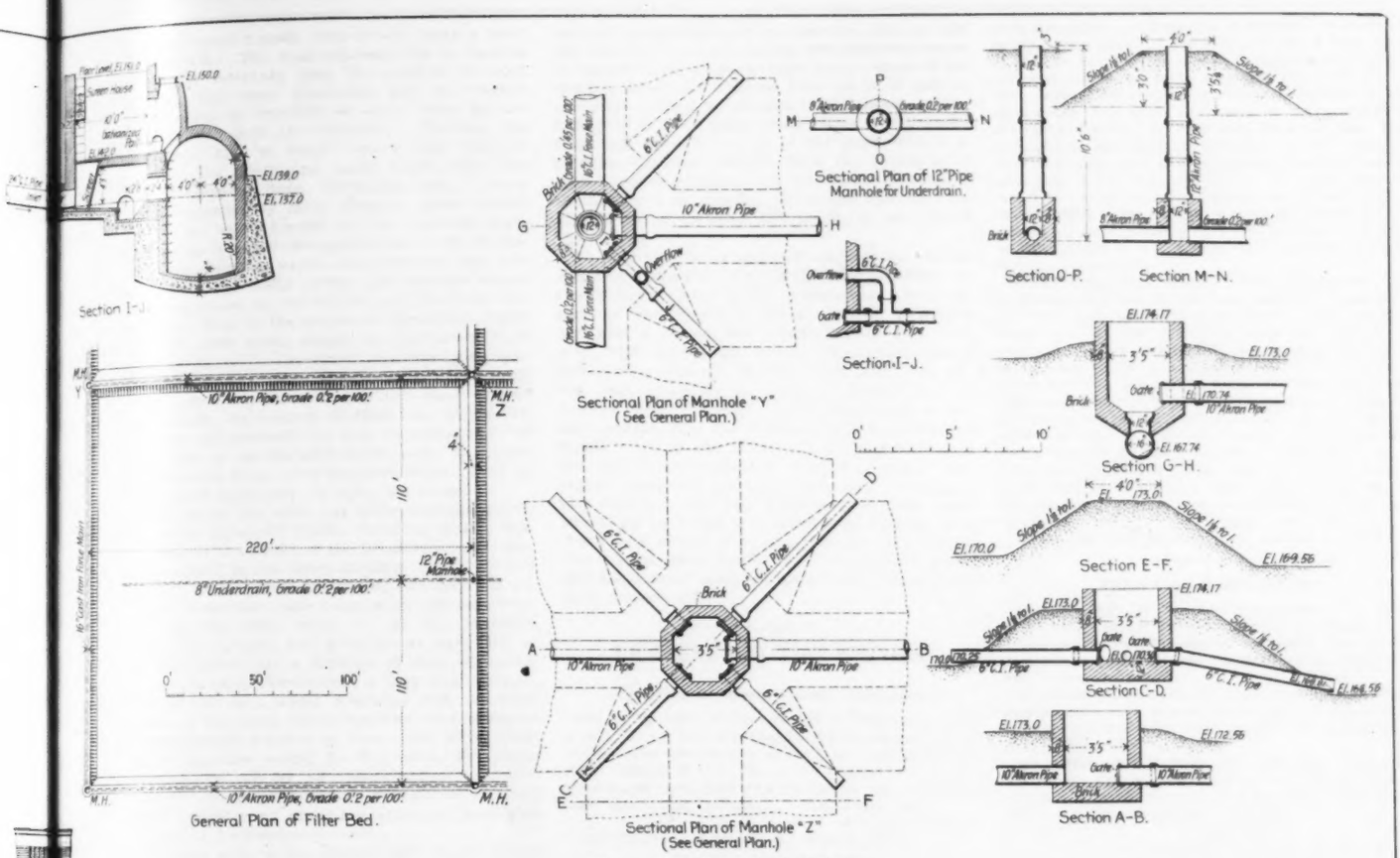


FIG. 4. DETAILS OF FILTER BED.

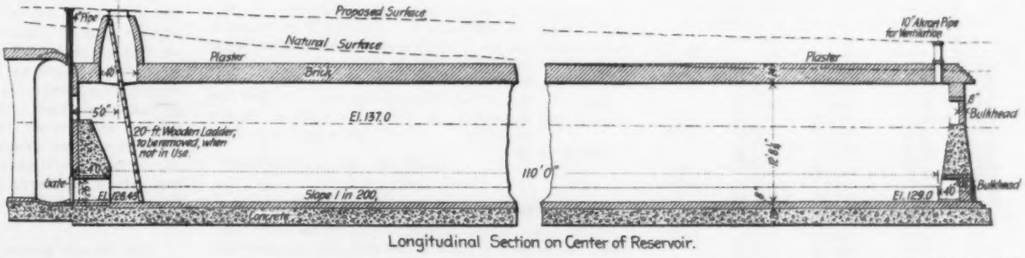
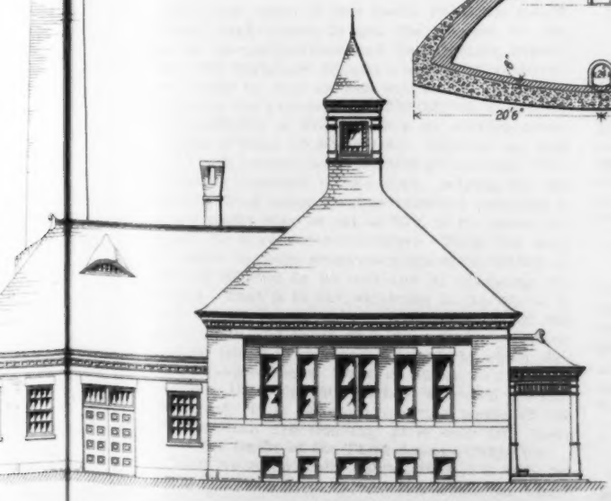


FIG. 5.
SIDE ELEVATION
OF
PUMPING STATION.



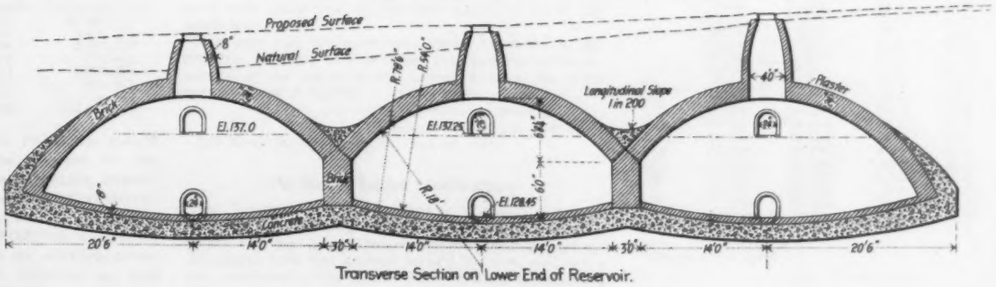


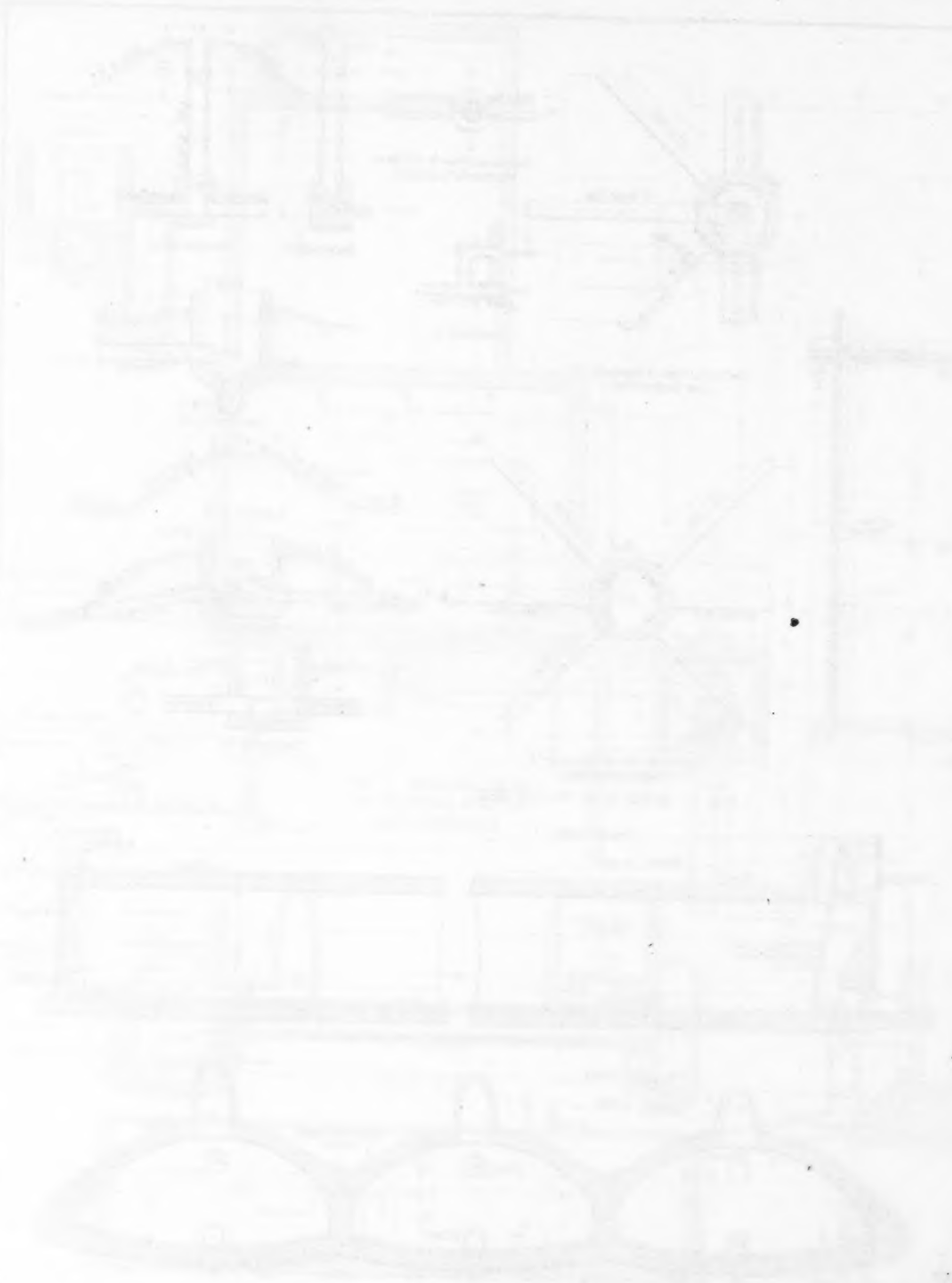
FIG. 3. SECTIONS THROUGH RESERVOIR.

SEWAGE DISPOSAL WORKS,

NATICK, MASS.

S. M. Gray, M. Am. Soc. C. E., Engineer.

CHAS. HART & SONS, LITH., 26 VESEY ST., N. Y.



proposed rapid transit road would carry a very heavy traffic. The local stations will be located at shorter intervals than the present elevated stations, and their platforms will be reached by one-third to one-fifth as many steps as are required to reach the elevated. Further, the Broadway line is much nearer the "gravity axis" of the north and south traffic than the present elevated lines. Certainly, then, a very large proportion of short distance riders would prefer the rapid transit to the elevated road. Now let us consider the competition of the Broadway cable line to which, we presume, our correspondent especially refers. Its average speed, including stops, is, we believe, not far from five miles per hour in the section of Broadway below 14th St. This speed cannot be increased; it is more likely to be decreased, as Broadway constantly becomes more and more crowded with traffic. In contrast with this the rapid transit local trains, by reason of their use of electric traction will probably be able to make quite as good time as the elevated trains make now, notwithstanding their more frequent stops. That is, they would make, say, 12 miles per hour.

Next, let us see what our correspondent means by "short distance" traffic. Does he realize that the bulk of the traffic of the Broadway cable line, for example, is not short distance traffic by any means. At a venture we should say that not 1% of the Broadway cable passengers ride less than 5 blocks (¼ mile). Some 5% to 15% probably ride under ½ mile, and probably at least 50% of its passengers ride a distance of over 1½ miles, or, say, in time, 15 minutes. A very large proportion of this 50% would doubtless seek the local trains of the rapid transit railway, and probably a considerable number of those who travel from ½ to 1½ miles would do the same. For these reasons, we can by no means accept as "self-evident" our correspondent's proposition that the rapid transit road could not attract a profitable volume of long-distance traffic.

Turning now to the second part of our correspondent's criticism. We would say emphatically that we should by no means favor the construction of the rapid transit road by the city did we not believe that instead of a certainty of loss, as our correspondent claims, there is a certainty of profit, as great a certainty, at least, as can be found in any transportation enterprise now before the public. Let us see what the traffic amounts to for which the proposed New York rapid transit road would compete. According to the last report of the New York Railroad Commission the traffic and earnings of the principal north and south passenger railways on Manhattan Island were as follows:

Company.	—Year Ending June 30, 1895.— No. of passengers.	Gross earnings.
Manhattan	187,614,985	$9,380,749
Metropolitan	119,358,169	5,484,323
Third Avenue	49,500,000	2,457,292
Eighth Avenue	14,897,218	744,861
N. Y. & Harlem	20,059,174	1,002,958
Second Avenue	19,099,200	954,964
Total	410,528,746	$20,025,147

Now, how much of this traffic must the Rapid Transit road secure to pay the interest on the cost of its construction, and its operating expenses? The engineers' estimates of cost of construction, made by men as well entitled to confidence as any in the profession, is $39,000,000, increased by $11,000,000, or 28%, to allow for contingencies, making a total of $50,000,000. Interest on this at 3% will amount to $1,500,000 per annum. The operating expenses of the road, judging by the experience of other electric railways carrying a heavy traffic may be set at 65% of the gross receipts, as a conservative figure. Then the road will have to make gross earnings of $4,286,000 to pay the interest on its cost and its operating expenses. That is to say, referring to the above, it will have to carry a little over one-fifth of the total north and south passenger traffic on Manhattan Island, which now amounts to about 85,000,000 passengers. That is about 45% of the number that the Manhattan Elevated carried last year. It is about 71% of the traffic of the Metropolitan Traction Co. It is only 70% more than the traffic of the Third Avenue Cable Ry.

Now, we respectfully submit that it is very far from extravagant to expect that a railway which can carry passengers from point to point in half the time now required by the best existing means of transport can secure as large a percentage of the existing traffic as this as soon as it is put in operation. There is, in fact, every reason to believe that a much larger percentage of the traffic than this would fall to it, at the start; and it is likewise perfectly certain that the increase of traffic which will come as the great unoccupied tracts above the Harlem River are built up will almost all go to swell the traffic of the Rapid Transit system.

We can take little space to answer our correspondent's queries respecting the influence of the "Greater New York" scheme upon the enterprise. No doubt it would benefit Brooklyn and Staten Island real estate holders if a Chinese wall were built across Manhattan Island somewhere between Central Park and 14th St., but that is hardly a legitimate reason for its construction. We have never been able to see any promise that the Greater New York scheme would result in any better municipal government for the cities interested than now exist, and this is really the only reason for its consummation that is of any real weight. If its first fruits should be to defeat the attempt to furnish New York city proper with the transportation facilities it so urgently needs, those who bring it about will have little reason to congratulate themselves upon their work.

LETTERS TO THE EDITOR.

Formulas for Curved Chords—Correction.

Sir: In my letter which appeared in Engineering News of May 21, one word was inserted and two changed by the printer.—The eleventh line should begin "cut by the section," instead of "cut out by the section" and, in the seventh and tenth lines from the bottom, the word "position" should read "portion." Yours very truly,

Benj. F. La Rue.

Coal Exchange, Scranton, Pa., May 23, 1896.

Transmission of Power by Wire Ropes.

Sir: An error was made in the article on "Transmission of Power by Wire Ropes," in your issue of May 7. The figures in the first column of table II. represent the values of X and are the ratios of radii of sheaves to diameters of wires, and not the ratios of diameters, as stated. You will find it correct in the paper that I gave you, and it was an oversight of mine in not correcting this when I went over the proof. Yours truly,

Wm. Hewitt.

Trenton, N. J., May 25, 1896.

Depth of Water in the Erie Canal.

Sir: Your usually correct journal has, in error, stated in your issue of May 21st that a draft of 5 ft. is the maximum now practicable in the Erie Canal; 6 ft. is the maximum.

It is true that our boats were loaded but 5 ft. on the first trip this year to New York, but that was solely on account of the nature of our cargo, which for the most part consisted of lumber. Yours truly,

Chas. E. Wheeler, Manager,
Cleveland Steel Canal Boat Co.

163 River St., Cleveland, O., May 26, 1896.

The Size of Printed Specifications.

Sir: Referring to the new issue of "Cooper's Specifications for Steel Railroad Bridges and Viaducts," I am glad to see that Mr. Cooper has wisely discarded the old inconvenient form and adopted instead the 8vo. size, 6 × 9 ins., I presume. This is also the size of the Baltimore & Ohio Railroad Bridge Specifications, and I know of no other. I have strenuously advocated this rational size for the last ten years and it is some little consolation to have made at least one convert in that time.

Yours truly, Emile Low, M. Am. Soc. C. E.

Saltville, Va., May 26, 1896.

(We can add at least two to our correspondent's list of specifications of the standard pamphlet size, 6 × 9 ins., viz: "Waddell's Specifications for Highway Bridges," and "Cummings' Electric Light Specifications." Doubtless there are others; and we fully agree with our correspondent that this size for specifications is much to be preferred to the old "legal cap" form.—Ed.)

The Proper Position for Sewer Underdrains.

Sir: Where subsoil drains are placed directly under the pipe carrying the sewage proper, they are not only "in such a situation that inspection is difficult," as remarked by Mr. Sidney Smith, in his letter published in your issue of May 21, but they are in such a situation that repairs are very difficult to make, and certainly could not be made without the removal or serious disturbance of the pipes above. The writer now places all subsoil drains at one side and about 1 ft. lower than the larger pipe. This arrangement eliminates all difficulties at sewer intersections met with when smaller subsoil drains are laid on each side of the large pipe and at the same grade or nearly so. At the bottom, manholes are divided into two compartments so the working of the subsoil drains may be seen at all times. Another advantage of this arrangement is that, except in soft ground, the large pipe may be laid in a natural bed.

Subsoil drains, with separate outlets, are of great value in diverting the clear ground water from the sewage when the latter must be treated as at Waterloo, Ont. (see Eng. News, April 2, 1896), where the writer laid a 9-in. subsoil drain along with the 15-in. pipe carrying the sewage proper, from the town to the nearest outlet, a distance of about 4,000 ft., and then a 6-in. pipe from this to the filter beds, about 2,000 ft. more. Both of these pipes ran full for some days in the spring, and they are now running about half full, and the water is quite clear and tasteless, being used for drinking purposes by the workmen. If there were no subsoil drains, this water would, without doubt, find its way into the large pipe at the joints, and the quantity of sewage to be treated would be very much increased. Yours very truly,

Berlin, Ont., May 25, 1896. Herbert J. Bowman.

Elastic Limit of Steel Castings.

Sir: Mr. Baldt, of the Penn Steel Casting Co., differs from me as to the relative value of an 8-inch and a 2-inch section for determining the elastic limit of steel castings, and believes that the 2-in. section gives sufficiently accurate results.

In support of his claim, Mr. Baldt furnishes the accompanying tests made on material for the U. S. Army, which requires a 2-in. section, while the U. S. Navy requires an 8-in. section.

An examination of these tests will show that, while the elastic limit in some of them exceeds the ultimate strength by more than 50%, the safe limit for a specification is 45% of the ultimate strength.

Yours truly,

A. C. Cunningham, C. E., M. Am. Soc. C. E.

51 State St., Albany, N. Y., May 23, 1896.

Report of Tests Made on Acid O. H. Steel for Gun Carriage and Fittings, Made by the Penn. Steel Casting & Machine Co., for the Ordnance Dept., U. S. Army.

Cast No.	—Stress in lbs. per— sq. in. Elastic.	Ultimate.	Per cent. of strain.—Elastic Elongation in 2 ins.	Reduction of area.	Ultimate
736	31,500	55,750	20.8	25.8	56.5
"	31,100	59,000	22.0	23.1	52.7
"	30,300	59,500	25.8	24.4	50.9
735	32,000	60,500	25.2	34.4	52.9
736	28,500	61,500	25.6	31.5	46.4
"	34,000	62,050	29.0	29.5	54.8
"	31,500	62,500	28.3	26.2	50.4
735	34,000	63,000	28.5	25.2	53.9
736	32,500	63,000	36.2	53.1	51.6
"	33,100	63,000	33.4	49.2	52.5
"	34,250	63,000	24.8	32.5	54.4
"	32,750	63,500	36.8	54.1	51.6
735	30,000	63,500	36.0	54.1	47.3
"	31,750	64,000	28.0	33.5	49.6
"	30,000	64,000	33.0	45.6	46.9
"	32,000	64,500	33.0	44.0	49.6
"	30,500	64,500	30.8	48.6	47.3
"	38,500	65,500	34.1	52.5	58.8
"	37,500	65,500	33.5	47.2	57.2
"	37,000	66,250	32.5	49.7	55.8
735	37,000	66,500	34.6	56.0	55.6
1,005	31,500	67,500	28.8	40.3	46.7
735	37,000	68,250	32.0	48.9	54.2
1,005	33,750	72,000	26.2	33.8	46.9
"	33,000	72,500	26.2	36.0	45.5
1,014	35,000	73,500	28.3	21.0	47.6
1,019	34,000	74,000	29.5	25.8	45.9
560	37,000	75,000	27.6	38.8	49.3
"	37,250	75,500	28.5	40.7	49.3
1,017	33,500	75,500	25.8	31.1	44.4
557	36,500	76,500	23.0	36.9	47.7
"	37,000	77,500	21.5	31.2	47.8

All fractures silky.

Inserting Advertisements in Specifications.

Sir: A question of professional propriety in regard to the placing of advertisements on the backs and inner pages of scientific papers, etc., published in pamphlet form has recently been brought to the writer's notice. This advertising is considered as a legitimate business operation by the various railroad companies when they issue descriptive routes, etc., and they have no hesitation in calling upon the shippers over their lines to place their cards in these books and to charge them a pretty stiff rate for the advertising thus given.

The transactions and proceedings of the American Society of Civil Engineers are also publishing advertisements of contractors and parties dealing in supplies of necessity to engineers. In fact it is quite a general custom to insert these advertisements in most of the pamphlets issued by engineering and technical societies. This being the case, would an engineer in drawing up a specification for structural work, trespass on the grounds of professional decorum if he should follow the

examples above mentioned and allow the publisher of his specifications to insert advertising matter of most interest to the parties who would use the specifications?

The writer knows of no case where an individual engineer has allowed this to be done. Would this kind of advertising suggest a possibility of an engineer having called upon his friends, the contractors, to pay a tribute? As this is a matter of public interest, an expression of opinion through your columns would be interesting.

Respectfully, Engineer.

(We should say that the best rule to follow in all matters of this sort is to refrain from publishing advertising wherever the business relations between the advertiser and the publisher are, or may be, such as to cause the advertiser to take space in the publication for some reason other than the desire to advertise his goods.—Ed.)

River Pollution at Richmond, Indiana.

Sir: Some mention has been made in the Engineering News (May 7—Ed.) of a damage suit for the pollution of a stream, recently decided against the city of Richmond, Ind., which possesses some features of interest to those places which may be similarly situated.

Richmond is a city of some 23,000 inhabitants, and lies on both banks of the Whitewater River, a stream averaging, perhaps, a flow of 25,000,000 gallons daily. The main part of the city is on bluffs, from 60 to 100 ft. above the bed of the stream, thus giving abundant fall for the discharge of sewers into the river. The construction of sewers was begun about 20 years ago, and has been carried on almost continuously since. At present there are about 17 miles of sewers in use, all discharging into the river. The combined system is used. Automatic flush-tanks are placed upon the most of the sewers, and the remainder are flushed periodically with hose. The water consumption of the city is very large, the Water-Works Co. furnishing, on an average, 25,000,000 gallons per day. Besides this, there is a large amount of spring water and seepage which is taken into the sewers, thus largely diluting the flow. Along the river are many factories, etc., which discharge directly into the stream, the worst of these being a paper mill, a gas plant, a tannery and several slaughter houses.

The plaintiffs in the suit were the owners of a woolen mill, whose plant is about one-half mile south of the city limits; their dam and head gate being about 300 ft. from the corporation line, 1,500 ft. from the nearest slaughter house and 1,800 ft. from the closest sewer outlet.

The suit, as originally filed, asked for damages, and a perpetual injunction against the emptying of sewage into the river. Before the case came to trial the decision of some other court in the state caused the plaintiff to abandon the effort for an injunction, and the case as tried was simply for damages against the city.

The trouble was precipitated by the dry weather of the last three years, the water in the river being very low, and thus failing to carry off the filth. The average yearly rainfall of this region is 39 ins., and since May, 1893, our total shortage in precipitation is about 44 ins. This, of course, has caused very low water in all the streams in the vicinity. Even streams free from the pollution of cities and towns are almost stagnant, and covered with offensive matter.

The points of defense were: That the trouble was largely due to the extraordinary shortness of rainfall; that no territory was drained into the river that was not naturally a part of that watershed; and that other and worse pollution than the sewers existed, by reason of the slaughter houses, gas works, etc., draining directly into the river, and that these last, in fact, were the principal causes of the trouble.

The accompanying table shows the result of tests made by Prof. J. N. Hurty, Secretary of the State Board of Health, to ascertain the character of the river water and sewage in various places in the city. From the table it will be seen that the worst sewage comes from the North E St. sewer, and contains 61 parts solid in 100,000, thus being only about one-third as bad as the average American sewage, which contains 200 parts solid in 100,000. Authorities state that a stream can carry 5% of its volume of average American sewage without material injury. On this basis the Whitewater River could carry 15% of its volume of our sewage during its minimum flow, if other manufacturing waste were excluded, whereas the gagings show that the entire discharge from the sewers is only about 7% of the volume of the river.

The table also shows that the pollution arising from other sources, notably the slaughter houses, is much worse than that from the sewers. This is no more than could be expected, since all the waste and offal from the animals killed is thrown directly into the river. The gas works also discharge large quantities of waste oil into the stream, which is very offensive to the smell, and is deadly to the fish.

The plaintiffs asked for $20,000 damages; the amount awarded was $1,350. This was allowed for "injury to the rental value of the property." The decision did not state whether this was on account of the pollution from the sewers entirely, or for the negligence of the city in allowing other and worse sources of pollution to exist within its jurisdiction. The case will be carried to the higher courts.

Fred. R. Charles.

Richmond, Ind., May 14, 1896.

Analysis of River Water and Sewage, Richmond, Ind.
(Parts per 100,000.)

	River above 16th St.	N. "E" St. sewer.	River above 6th St. sewer.	Mouth of 6th St. sewer.	River 150 ft. below 6th St. sewer.	River at 1st slaughter house drain.	River 75 ft. below 1st slaughter house drain.	Head race 150 ft. above mill.
Org'nic & volatile.	14.8	30.2	15.0	24.0	14.6	68.2	31.2	33.8
Total solids.	38.8	61.0	27.6	48.0	34.4	97.6	50.0	55.0
Chlorine.	0.8	5.0	1.1	5.4	1.2	8.6	1.7	1.3
Nitrites.	+	+	+	+	+	0	++	++
Nitrates.	+	+	++	0	++	0	+++	++++
Oxygen absorbed.	0.3	1.2	0.5	0.8	0.5	9.0	0.6	0.6

Errors in the Use of the Gradienter.

Sir: It may be worth while to give a more particular account of the necessarily inherent defects of the gradienter than was given in "Van Nostrand's Magazine" for May, 1872.

The successful use of the micrometer in astronomical instruments has apparently created the impression that the same principle could be satisfactorily applied in the form of the gradienter; but it should not be forgotten that "circumstances alter cases." The astronomical micrometer is a very perfectly formed screw that moves the light micrometer slide or web-frame inside the telescope at the focus of the eyeglass, and minute angular measurements are made by counting the number of revolutions and parts of a revolution of the screw. It has been found that errors of scarcely determinable amount are caused by a lack of perfect straightness in the screw, if it works with a square shoulder on a flat surface; and if the screw works with a spherical shoulder in a hollow cone, almost inconceivable accuracy is required for the adjustment of the matrix of the screw in the slide to the axis of the cone and both to the direction of the motion of a point in the slide. Besides, any such shoulder where oil is used, will, if not perfectly protected, become inaccurate from layers of dust and oil of variable and uncertain thickness. If such sources of error have been found serious in quiet, well closed astronomical observatories, how much less likely is it that apparatus of that kind, even if closely similar in construction, would work well in the rough, dusty field work of a surveyor! To be sure, the astronomical measurements are extremely minute; but in surveying, too, rather fine measuring is aimed at with the gradienter, say, at most, a hundredth of a foot on the rod, at a distance of several hundred feet.

If we consider the details of the construction of the gradienter, we shall find several occasions for inaccuracy in its work; so much so, that it has sometimes been found necessary to make two complete turns of the gradienter screw before the telescope moves at all.

1. The gradienter screw is far more exposed to dust than an astronomical micrometer screw, and, even if made in the beginning, with the extreme skill that such screws require, is very liable to wear, so as gradually to become comparatively loose. There may then arise a certain amount of "lost motion" or "back-lash," so that the screw may have to be turned to some extent before producing any effect on the lever-like clamp-arm that communicates its motion to the telescope. The particles of dust or oil, perhaps oil stiff with cold or gummy with drying, may be so unevenly distributed as to give less uniformity to the motion of the screw than such delicate measurements really require.

2. The screw, with its shank, is somewhat long, and with the ordinary strains upon it, even without the violent pulls and positive blows that are so liable to occur in field work, is capable of becoming slightly bent, and so in different parts of each turn would produce unequal effects on the motion of the telescope.

3. The gradienter screw does not merely move directly a light micrometer slide, but a long lever, namely the clamp, transmitting the movement ultimately to the telescope itself. The weight of the parts and that of the telescope, especially if this be not perfectly balanced, and the friction of the several bearings, particularly when the lubricating oil is stiff with cold or gummy or dusty with long exposure, or when the clamp is not completely loosened, or the fitting of the screw or of the telescope axle rather tight, make together considerable resistance to be overcome by the screw. When the screw is turned, there is a strain and a slight yielding of the somewhat numerous intermediate parts before the telescope moves. The yielding may be not only the back-lash of the screw, but either a minute bending of the lever-like arm of the axle-clamp of the telescope, or a pushing of the axle against one side of its bearing, if not extremely tight-fitting, and the closeness of the fitting would in time become slightly less under ordinary conditions of dusty use, or according to the lubrication.

The truly practical application of the principle of the astronomical micrometer to surveying instruments is in the adjustable cross-hairs or wires for stadia reading, and such stadia work is more trustworthy for distance measuring and less laborious than the corresponding gradienter work. The arrangement of the adjustable cross-hairs is indeed closely similar to the micrometer slides. The cross-hairs are placed horizontally upon small slides that are moved up or down by screws that pass through the top and bottom of the telescope tube. The cross-hairs, like those of the astronomical micrometer slides, move very closely alongside the fixed vertical cross-hair of the telescope, so that they shall all be well in focus together, yet so as to be quite free from "fiddling." As the adjustment is not a frequent operation, the screw is not often moved, and is consequently not unfavorably affected by the dustiness or exposure of the field work, as compared with the astronomical observatory. The head of the upper screw on the top of the telescope, if wholly unprotected, is indeed liable to be accidentally moved by twigs of trees, when carried along the line; but is easily covered enough by a small cap open at two sides. Any movement of either screw is readily detected by the discrepancy caused in the readings of the upper and lower cross-hairs, but with such a simple cap over the upper screw it is extremely rare that any disturbance of a screw occurs.

Such adjusted stadia wires in a good telescope are of course free from the defects of the gradienter and so give the distance much more exactly; and, indeed, enable distances to be read directly from a level rod with as great exactness as exceptionally good chaining, especially if the length of sight is kept within the moderate limits that good topographical work requires at any rate. The paper by Prof. L. S. Smith, last year (Eng. News, June 6, 1895), has even demonstrated the great usefulness of the stadia with long sights and unfavorable atmospheric conditions, if certain precautions be taken.

But success with the stadia requires that the image of the rod should be well focussed upon the cross-hairs. If the lenses of the telescope are of such a character as to have a curved field, that is, so that the focussed image has a curved shape, and so that either the eyepiece or the object glass can be moved a short distance back and forth without apparent harm on the whole to the sharpness of definition of the image, then there is danger that the image of the rod may be allowed to rest slightly in front of the cross-hairs, or behind them, instead of perfectly coinciding with them. In case of such failure to coincide, the readings would be erroneous, from parallax; and that is doubtless frequently the occasion of inaccuracy with the stadia. The Heller & Brightly telescopes, however, have a remarkably flat field, that is, give sharp definition only at one point, and the image of the rod, if distinct, must be precisely upon the cross-hairs, if they are also distinct. Under such circumstances the reading is much more likely to be exact. If a telescope is so unfortunate as not to have a flat field, the gradienter has for distance-measuring a greater advantage than it would otherwise have; for the central cross-hair intersection at the axis of the lenses would be unaffected by parallax.

For the measurement of vertical angles, as in establishing grades, direct measurement with the vertical circle, or vertical arc of the transit, is much better than the gradienter. Not only are the gradienter errors avoided, and the readings easily as close as a gradienter in good condition can be trusted, but the work is more expeditious. No special adjustment at each station is required answering to the adjustment of the zero of the screw to the zero of its scale. In establishing grades, the telescope can be set with the vertical circle to the angle corresponding to the percentage grade; or, even the arc can be graduated, if desired, with such percentages. The need of tabular work is less, if anything, with the simple vertical circle than with the gradienter.

Moreover, there is great gain in the simplicity of the construction and the consequent accurate working of the instrument, if the gradienter be avoided; for, in surveying instruments, no less than in machinery, simplicity is a decided advantage. It is a point that is too much overlooked, especially by the ill-instructed. For example, a transit telescope is sometimes made with four adjusting screws to keep a ring in place to guide the movement of the object-glass tube exactly in line with the axis of the lenses, and like screws and a ring for the eyepiece. The half-informed engineer may admire such ingenuity and apparent effort at the greatest precision, but the wear upon the inner surface of these narrow rings will soon destroy the perfect uniformity of shape of the rings or of the tubes, even if the form and fit were originally perfect. The form of the tubes, indeed, is not likely to be perfect; for one object of the arrangement is to enable the use of tubes of inferior quality. Moreover, there is a great liability to a variation of the adjustment from an overstraining of the screws and from changes of temperature. Such wear or originally imperfect form or disarranged adjustment make it absolutely impossible for the apparatus to cause the tube to move precisely parallel to the axis of the lenses. Far better is it, though requiring more skill and care in the instrument maker, simply to fit the tubes accurately inside the main tube. Then, with their long and perfect bearing, they work well permanently.

It is evident, then, that the complicated gradienter is an ill-judged attempt to make use of the principle of the astronomical micrometer under such unsuitable conditions as must insure a complete failure in precision.

But a practical application of the principle is in the adjustable stadia wires, and they measure distances not only more accurately but more easily than the gradienter can. For establishing grades and measuring vertical angles, the vertical circle is not only more exact but more convenient than the gradienter, and at the same time has the important advantage of much greater simplicity of construction.

Benj. Smith Lyman.

708 Locust St., Philadelphia, Pa., April 29, 1896.

Notes and Queries.

W. A. D. askes for information as to the proper grades for the track of a "roller coaster" or switch-back for a pleasure resort.

EXPERIMENTS WITH AUTOMATIC MECHANICAL STOKERS.*

By J. M. Whitham,** M. Am. Soc. M. E.

Stokers in General.

The recognized advantages of mechanical stoking are:

1. Adaptability to the burning of the cheapest grades of fuel.

2. A 40% labor saving in plants of 500 HP. or more when provided with coal-handling machinery.

3. Economy in combustion, even under forced firing, with proper management.

4. Constancy and uniformity of furnace conditions, the fires being clean at all times, and responding to sudden demands made for power. This should result in prolonged life of boilers.

5. Smokelessness.

The disadvantages are:

2. High first cost, varying from $25 to $40 per sq. ft. of grate area.

2. High cost of repairs per annum, which, with some stokers, is as much as $5 per sq. ft.

3. The dependence of the power plant upon the stoker engine's workings.

4. Steam cost of running the stoker engine, which is from 1-5 to 2-5 of 1% of the steam generated. This is about $50 a year on a 10-hour basis for 1,000 HP., when fuel is $2 a ton.

5. Cost of steam used for a steam blast, or for driving a fan blast, whenever either is used. This, for a steam blast, from 5 to 11% of the steam generated by the boilers, and from 3 to 5% for a fan blast. This amounts to about $1,000 a year for a steam blast, and $500 a year in fuel for a fan blast, for a 1,000 HP. plant on a 10-hour basis, when fuel is $2 a ton.

6. Skill required in operating the stoker. Careless management causes either loss of fuel in ash, or loss due to poor combustion when the coal is too soon burned out on the grate, thus permitting cold air to freely pass through the ash.

7. The stoker is a machine subject to a severe service, and, like any other machine, wears out and requires constant attention.

This paper is intended to show the performances of the Wilkinson stoker, and the use of steam in combustion; the operation of the Coxe stoker using a graduated fan blast, and of the Babcock & Wilcox stoker under a strong natural draft. The Coxe is designed for use with buckwheat and rice grades of anthracite coal, the Wilkinson stoker is adapted to both anthracite and bituminous coal, while the Babcock & Wilcox stoker is used only with bituminous coal.

The Wilkinson Stoker.

This stoker consists of hollow bars, as shown in Fig. 1, set at an angle of about 25° with the horizontal, with open ends. The top of the bars is stepped, and tuyere-shaped openings, about ¼ × 3 ins. are provided in each riser.

The bars are carried, at their ends, on hollow boxes. The lower box, or bearing bar, has finger grates, about 15 ins. long, secured to its rear face. The bars are set 4 ins. c. to c., so that, practically, the air openings are restricted to the risers, already noted. Adjacent bars move in opposite directions by a system of toggles controlled by a compound spur gearing, which is driven by the stoker engine.

The feeding is accomplished by the motion of the grates, no feed roll or pusher being required.

Steam jets at the open upper end of each bar force into the fire the air needed for combustion. There is one jet to each bar, having an opening of about 3-32 in.

This stoker is specially well adapted to the burning of small sizes of anthracite coal, and is also used with bituminous coal.

Stoker Trials.—Thirteen trials of this stoker, with various anthracite coals and various boilers, have their results summarized in Sheet No. 1.

The results are all good, and indicate that this stoker is nearly as economical when working with forced as with gentle fires. The range of the rate of combustion varied from 14.8 to 45.4 lbs. of dry coal an hour per sq. ft. of grate.

Effects of Steam on Combustion.—Steam in passing through a bed of burning coal must extinguish the fire or become decomposed. The steam, in practice, acts upon the coal as in a gas producer, and the combustion chamber is filled with burning gases. With natural draft and anthracite coal, the flame is seldom longer than from 8 ins. to 36 ins., yet a steam blast will make a flame 40 ft. long if permitted to do so. The effect of the steam, then, is to gasify the coal. This results in a more uniform distribution of the effective heating surface of the boiler, reduces local injury, gives a more uniform expansion to the parts of the boiler, but is apt, if not properly controlled, to cause a loss of heat in the stack. Steam prevents the formation of clinkers, thus prolonging the life of the bars and furnace linings.

Steam Used by the Wilkinson Stokers.—While conducting trials 253, 254, 290 and 291, separate trials were made on an auxiliary boiler supplying the steam jets and the stoker engine. The exhaust from the stoker engine was condensed, so that the amount strictly chargeable to the jets would be known.

Thus in trial 253 we have, when burning Lykens Valley rice coal:

Evaporated HP. developed by boilers		691.00
Boiler HP. used by stoker engine	1.42	
Boiler HP. used by stoker jets	73.21	74.63
Available boiler HP.		616.37
Power developed used to operate stoker engine, %.		0.21
Power developed used to operate stoker jet, %		10.59
Power developed used to operate the stoker, %		10.80
Corrected evap., 212° F., per lb. of combustible, lbs.		9.34

In trial 254 air was supplied by a fan driven by a small slide-valve engine. The air was led to the hollow posts carrying the front bearing bar or box, from whence it entered the hollow grate bars and passed into the fire. The open ends of the grate bars were closed, the steam jets being removed. Clinker formation was prevented by turning the fan engine's exhaust into the air conduit, and also by bleeding so much live steam into the bars as was necessary to protect them. Burning Lykens Valley rice coal, we found:

Boiler HP. developed		410.5
" " used by fan engine	13.15	
" " as live steam bled into grates*	23.1	
" " used to drive stoker engine	1.03	37.28
Available boiler HP. remaining		373.22
Per cent. power developed used operate fan engine		3.21
" " " " " protect grate bars		5.62
" " " " " drive stoker engine		0.25
Per cent. power dvlpd. used drive fan, stoker, etc.		9.08
Engine HP. developed by fan engine		5.92
Steam consumption fan engine,, lbs water, 212° F., per engine HP. developed, lbs.		76.6
Corrected evap, 212° F., per lb. of combustible, lbs.		10.88

*To prevent injury to them.

Comparing these two tests, we see that about the same percentage of the steam generated was required when running with the fan as when using the steam blast, while this stoker can be pushed harder with the steam blast.

If no live steam had been used to prevent clinker formation on test 254, then we should have been able to compare the steam and fan blasts as follows:

Items.	Steam blast test	Fan blast test
Percentage:	253.	254.
Boiler capacity to operate stoker engine.	0.21	0.25
Required for the steam blast	10.59	....
Required for the fan engine	...	3.21
Total	10.80	3.46
Relative amounts, about	100	33⅓

In trials 290 and 291 the steam consumption was found to be as follows, the stokers operating in the usual manner with steam blasts, burning Philadelphia & Reading Coal Co.'s buckwheat coal:

Items.	Kind of test. Test 290. Economy.	Test 291. Capacity.
No. boilers tested, run by stoker engine	2	1
Dry coal burned, hr., pr. sq. ft. grate, lbs	32.5	45.4
Boiler HP. developed	840.4	553.1
" " used by stoker engine	2.2	2.3
" " used by stoker jets	63.6	54.0
Total boiler HP. used by stoker	65.8	56.3
Available boiler HP. remaining	774.6	496.8
Boiler power used by stoker engine, %	0.26	0.42
" " " " " jets, %	7.57	9.76
Boiler power used by stoker, %	7.83	10.18
Cor. evap., 212° F., per lb. of combus,, lbs.	11.32	10.50

It is therefore evident that this stoker uses from 7.8 to 10.8% of the total steam generated, when the boiler is driven from 12 to 60% above its rating, providing the rate of combustion is from 20 to 45 lbs. of dry buckwheat an hour per sq. ft. of grate. This stoker is largely independent of the natural chimney draught. A steam or fan blast develops its own furnace draught (which is that useful for combustion), and the chimney draught is useful only in carrying the gases away from the furnace. If the chimney draft is inadequate for this light duty, then the blast comes to the rescue and pushes the gases away. In this latter case there is a positive pressure in the furnace.

Possible Rates of Combustion.—The accompanying table is a summary of independent investigations made by the writer to determine the range of combustion possible with the Wilkinson stoker. The first, second, third and fifth columns are the results of direct measurements, the remaining columns being deduced from them.

There is an excess supply of air up to a combustion of 30 lbs. of dry coal an hour per sq. ft. of grate. There was an almost perfect evaporative efficiency when burning 45.4 lbs. of dry coal an hour per sq. ft. of grate, while the table also shows that there must then have been an 11.2% deficiency in the air supply.

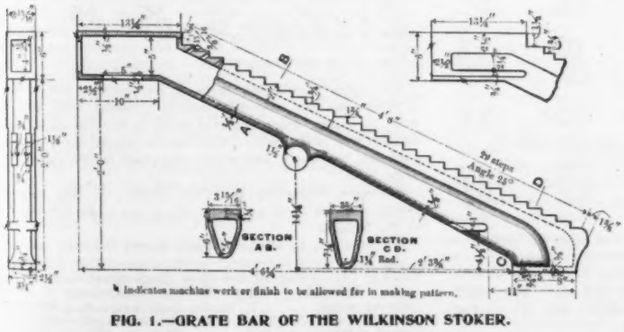


FIG. 1.—GRATE BAR OF THE WILKINSON STOKER.

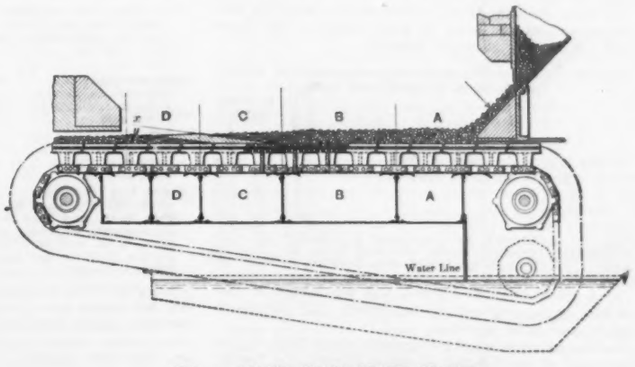


FIG. 2.—COXE'S CHAIN GRATE STOKER.

TABLE I.—Performance of the Wilkinson Steam Blast at Different Rates of Combustion.

Gage pressure steam at the jets, lbs.	Air discharged through buckwheat coal fire per hr., 1 jet, ¾-in. diameter, cu. ft.	Boiler HP. used to operate 1 steam jet.	Air per hr. given fire by use of 1 boiler HP. by a jet of steam, cu. ft.	Buckwheat coal burned per hour per sq. ft. of stoker grate, lbs.	Air supplied to burn 1 lb. of buckwheat coal, lbs.	Air theoretically required to burn 1 lb. of buckwheat coal, lbs.	Percentage of excess or deficiency of air supplied by stoker jets,
15	4,178	0.700	5,970	12.0	232	125	+85.6
30	4,717	0.825	5,718	18.0	157	125	+25.6
45	5,554	0.945	5,887	25.2	132	125	+ 5.6
60	6,625	1.180	5,615	32.5	123	125	— 1.6
75	7.642	1.290	5,924	41.5	111	125	—11.2
86	...	1.590	...	45.4	111	125	—11.2

Such a deficiency in air supply would seriously impair the efficiency of most furnaces, but is no serious drawback with this stoker, on account of the thorough diffusion of the air through the entire bed of coals. We may now state that this stoker has a range of combustion up to 45 lbs. of dry coal an hour per sq. ft. of grate.

It is common knowledge that ordinary furnaces, run with natural draft, use about 100% excess air for dilution, and that blasts in general use 50% excess. Table II. shows

*Condensed from a paper presented at the St. Louis meeting (May, 1896) of the American Society of Mechanical Engineers.

**131 South 3d St., Philadelphia, Pa.

TABLE VI.—TESTS OF WILKINSON'S AUTOMATIC MECHANICAL STOKER, MADE WITH VARIOUS BOILERS AND VARIOUS ANTHRACITE COALS.

No. of boiler trial	252	254	253	249	370	371	288	337	238	239	237	290
Duration of trial, hours	10	10	10	9	9½	14½	8	9	10	10	8	11
Type of boiler	Double dk hor. tubl'r.			Hor. tubular boiler.			National.		Babcock & Wilcox.		Babc'k &Wlcx.	Double deck Bbck & Wlcx.
Number in use	4			1	7		1	2	1		2	2
Total water-heating surface per boiler, sq. ft.	1,286			1,215	Total, 7,524.		3,850	3,850	1,253		2,180	4,225
Grate surface per boiler, sq. ft.	24			25	Total, 165.		62	62	20		28	45
Ratio of water-heating surface to grate surface	53.6			48.6	45.6		62.1	62.1	62.6		78	93.9
Height of stack above dead plate, ft.	88			116	....		115	115	....		....	Mech'l Draft
Steam pressure in boiler by gage, lbs.	99.1	101	98.7	102	96.5	96.7	80	102.1	89	88	102	130.4
Draft in ins. of water, ins.	0.34	0.30	0.40	0.25	0.53	0.52	...	0.75	0.25	0.25	0.25	0.60
Sum of blast and vacuum, or total draft, ins.	1.01	0.88	1.64	0.58	0.87	0.93	...	1.23	1.10	1.10	0.80	1.08
Average temperature of feed water, ° F.	135.3	148.2	127.0	178	181	170	160	194.4	196	196	183	44.1
Average temperature of escaping gases, ° F.	360	300?	385	442	435	435	...	365.0	510	405	505	....
Moisture in coal, %	2.0	3.0	1.5	5.0	5.0	5.0	2.25	4.5	4.0	4.0	4.5	4.5
Ash and refuse in dry coal, %	15.06	16.46	12.07	11.6	21.18	21.18	21.5	19.7	20.0	16.7	19.6	19.45
Moisture in steam, %	0.32	0.29	0.45	0.19	0.20	0.20	...	....	0.92	0.43	0.48	0.20
Water evaporated per lb. of dry coal from and at 212° F., lbs.	10.21	10.00	9.20	9.06	8.79	9.03	9.32	9.48	8.80	9.20	9.15	9.90
Water evaporated per lb. of combustible from and at 212° F. lbs.	12.02	11.97	10.46	10.36	11.14	11.45	11.87	11.81	11.00	11.04	11.38	12.20
Dry coal burned per sq. ft. of grate surface per hour, lbs.	21.5	14.8	27.0	20.14	22.3	22.3	31.9	26.3	30.2	21.3	33.7	32.5
Combustible burned per hour per sq. ft. of grate surface, lbs.	18.3	12.3	23.7	17.8	..	..	...	....	24.2	17.8	27.1	....
Water evap. from and at 212° F., hr. per sq. ft. w.-h't'g surf.	4.10	2.75	4.63	3.80	4.29	4.41	4.79	4.04	4.25	3.14	3.96	3.43
Water-heating surface to 1 boiler HP. developed, sq. ft.	8.4	12.5	7.4	9.2	8.0	7.8	7.2	8.5	8.1	11.0	8.7	10.0
Horse-power on a basis of 30 lbs. of water per hour evap.* HP..	611.8	410.5	691.0	132.3	935.9	961.4	543.1	901.8	154.3	114.0	500.3	840.4
Horse-power, builders' rating, HP.	428	428	428	100	627	627	350	700	190	109	400.0	750
Developed (+) above or (—) below rating, %	+42.9	—4.1	+61.4	+32.3	+49.2	+53.3	+52.6	+27.4	+41.6	+5	+25.0	+12.0
Dry coal burned per hour per boiler HP. developed, lbs.	3.38	3.45	3.75	3.81	3.92	3.82	3.71	3.64	3.92	3.75	3.77	3.48
Kind of coal used	Lykens Valley rice coal, anthracite.			..**..			Locust mountain bkwht.		Nanticoke buckwheat.	Shamokin bkwht. rice.	Schuylkill, bkwht.	Lykens Valley bkwht.	R.C.& I.Co.'s buckwheat.
Kind of blast	St'm.	Fan.	St'm.	St'm.	Steam.		Steam.		Steam.		Steam.	

*From temperature of 100° F. into steam at 70 lbs. gage pressure. **Wyoming Mine buckwheat.

that a 10% deficiency of air supply gives a boiler nearly the same theoretic absorbing efficiency as a 100% excess supply. The table is based upon the burning of 1 lb. of pure carbon. It shows the approximate flame temperatures, heat units developed, and heat units absorbed by the boiler when the external air is at 70° F., and the stack gases are at 525°.

TABLE II.—Results of the Burning of 1-lb. of Pure Carbon, with Various Amounts of Air.

Excess or deficiency of air supplied, %.	Temperature of the flame, deg. Fahr.	Heat units developed.	Heat units absorbed.
— 50	2,662	4,555	3,600
— 40	3,349	6,462	5,515
— 30	4,055	8,490	7,430
— 20	4,340	10,481	9,345
— 10	4,610	12,490	11,260
0	4,877	14,500	13,175
10	4,477	14,500	13,050
20	4,110	14,500	12,925
30	3,810	14,500	12,800
40	3,555	14,500	12,675
50	3,354	14,500	12,550
60	3,140	14,500	12,425
70	2,955	14,500	12,300
80	2,800	14,500	12,175
90	2,665	14,500	12,050
100	2,540	14,500	11,925

Summary Regarding the Wilkinson Stoker.—1. Small grades of anthracite coal pack closely upon the grate, and offer much resistance to the introduction of the air supply. They require a strong blast.

2. With the same draft, natural or otherwise, the rates of combustion and costs of small grades of anthracite coal are about as shown in Table III.

TABLE III.—Relative Rates of Combustion and Cost of Small Sizes of Anthracite Coal.

Grade	Size of coal (round holes, punched plates).	Relative rates of combustion for same draft.	Relative costs. At mine.	Relative costs. On cars, Philadelphia.
Pea	Through ⅞-in. and over 9-16-in.	100	100	100
Buckwheat	Through 9-16-in. and over ⅜-in.	85	57	72
Rice	Through ⅜-in. and over 3-16-in.	70	37	61

3. A steam blast, in general, will use from 5 to 11% of the steam generated in the boiler. The Wilkinson stoker blast is no exception.

4. The efficiency of the Wilkinson steam blast is less than that of other forms of steam blowers, the Young, McClave, and Eynon-Korting blower; yet for a given combustion rate, no more steam is used, because this stoker has a more perfect diffusion of the air through the fire than is possible with flat grates, and can secure a good evaporation with less air for dilution than can any other system of burning coal known to the writer.

5. Most anthracite coals of inferior sizes clinker badly if the fire is forced. Such clinkers freeze to the sides of the furnace and to the grates. This is especially true for fan blasts. But the effect of a steam blast is to chill the grates and non-combustible material against them, so that a clinker cannot form. The result is a prolonged life of bars and furnace linings.

6. In plants, subject to extreme fluctuations in power demands, the bars of this stoker are subject to a severe service. When an intensely active combustion has been required for a time and the demand ceases, the steam jets are shut off and the fire is, as it were, banked until the demand is resumed. In this case no air or steam, practically speaking, is given to protect the bars, and the white-hot coal against them may cause damage.

The Coxe Stoker.

Fig. 2 is a longitudinal view of this stoker. It consists of a traveling chain grate with a fire on its upper surface. The coal is fed by the motion of the grate at the front. There are four blast compartments, A, B, C and D, under the fire, connected by dampers or registers, so that the intensity of the fan blast may be varied in each compartment. Compartment A receives a gentle blast to ignite the coal. The ignited coal receives a heavy blast over compartment B, which burns out the volatile gases and partially burns the fixed carbon. Over C the coal is nearly burned out, while a gentle blast at D reduces the fuel to ash.

The trials of this stoker were in one of two double-deck Babcock & Wilcox boilers, 375 HP. each, equipped with the Coxe stokers. The general dimensions were:

Size of bed of fire .....7 ft. 3 ins. × 9 ft. 6 ins.
Grate area .....68.9 sq. ft.
Air openings in grate 18.8%
Air openings, width .....3-16-in.
One 30-in. Sturtevant fan blower to each stoker.
One 7½ × 7-in. 390 revs., 25-HP. Westinghouse standard engine for two stokers and two fans.

The sides of the furnace are protected by wrought-iron water backs, D-shaped in cross section, along the flat of which the coal is dragged, and through which water circulates under a slight pressure. On the trials the water was discharged into a tank and used as a boiler feed. The extent of the heating of the water depends upon the quantity supplied.

Trials of the Coxe Stoker.—Trials 332 and 333 were made with buckwheat coal. Analyses of this coal were made by Mr. John R. Wagner, with the following results:

	Percentages. Boiler test 332.	Boiler test 333.
Buckwheat coal analyses:		
Moisture in coal sample	2.02	2.42
Volatile combustible matter	4.45	4.95
Fixed carbon	79.28	76.18
Ash	14.25	16.45
Ash analyses:		
Moisture in sample	0.02	0.02
Volatile combustible matter	0.65	0.13
Fixed carbon	18.13	12.00
Ash	81.20	87.85
Slate test of coal:		
Pure coal	87.53	84.36
Slate and bone	12.46	15.63
Sizing test (through round holes, punched plates):		
Chestnut, 1½ ins. and over ⅞-in.	0.82	.....
Pea, ⅞-in. and over 9-16-in.	19.86	10.04
Buckwheat, 9-16-in., over ⅜-in.	61.09	73.36
Rice, ⅜-in. and over 3-16-in.	16.98	15.26
Barley, 3-16-in. and over 3-32-in.	0.68	0.80
Culm, 3-32-in.	0.54	0.53

Analyses of the flue gases were not made for these tests but the results were probably similar to the tests made two days earlier, when the same coal was burned with the stoker driven about as in tests 332 and 333. These analyses were also made by Mr. Wagner, and the average results were:

Trial No. 328, 8 tests. CO_2, 15.1; Free O, 4.3; Sum., 19.4%
Trial No. 329, 11 tests. CO_2, 12.9; Free O, 6.9; Sum., 19.8%

The operations of the stoker were as follows:

Trial No.	Speed of grate pr hr.	Thickness of fire grate in front.
332	54 ins.	10 ins.
333	100 "	10 "
334	80 "	10 "

The blast pressures and draft conditions are given in Table IV.

TABLE IV.—Draft Conditions of the Coxe Stoker Trials.

Items.	Draft in ins. of water. Buckwheat, coal, test 332.	Buckwheat, coal, test 333.	Rice coal, test 334.
Pressure in igniting compartment A*	0.14	0.25	0.44
In burning compartment B (Fig. 2)	0.31	0.56	0.80
In burning down compartment C*	0.24	0.49	0.73
In burning-out compartment D*	0.17	0.42	0.67
Of blast of air, average	0.24	0.43	0.68
Vacuum in furnace	0.10	0.15	0.24
Total furnace draft	0.34	0.58	0.92
Vacuum in stack flue	0.13	0.40	0.58
Total draft	0.37	0.83	1.26
Dry coal, hr. per sq. ft. of grate, lbs.	19.8	32.9	28.0

*Fig. 2.

The engine horse-power used to run the stoker and its fan blast varied with the manner of operating the stokers, but averaged about 10.8 HP. This, for a Westinghouse engine 7½ × 7 ins., must have called for about 20 boiler HP. In this event, the boiler developing about 500 HP., 4% of the steam generated would be charged to the Coxe stoker.

The trials recorded in Table VII. showed excellent results with this stoker. Each test covers a double column, the first part referring to the boiler only, and the other to the boiler and water-back combined. Assuming the 4% charge for operation to hold, we must deduct it from the apparent results to get the net results. The results previously found with the Wilkinson stoker, trial No. 290, will now be compared with the Coxe stoker, trial No. 332, both referring to a 375 HP. Babcock & Wilcox boiler, using P. & R. C. & I. Co.'s buckwheat coal, the boilers being run in each instance to secure best economy, i. e., to develop near their rated power. This comparison is made in Table V.

TABLE V.—Comparison of Net Results of Economy Trials made with the Coxe and Wilkinson Stokers.

	Coxe stoker trial, 332. Water back— Neglect'd.	Includ'd.	Wilkinson stoker trial 290.
Ash in coal, %	17.2	...	19.5
Moisture in coal, %	0.7	...	4.5
Dry coal burned per hour*	19.8	...	32.5
Total furnace draft, ins water	0.34	...	0.80
Total draft, ins. of water	0.37	...	1.08
Boiler HP. developed, pr boiler.	370.4	378.0	420.2
Boiler HP. available, pr. boiler.	355.6	362.9	387.3
Corrected evap., from and at 212° F., per lb. of dry coal, lbs.	8.87	9.17	9.12
Per lb. of combustible, lbs.	10.72	11.07	11.32
Ratio, heating to grate surface	61.3	...	93.9

*Per sq. ft. of grate, in lbs.

This table shows that there is no practical difference between the net economic results obtained with either form of stoker, when operated so as to develop about the rated power of the boiler. The Coxe developed the greatest capacity, because it had much advantage in the extent of grate area.

Summary Regarding the Coxe Stoker.—1. The stoker engine and fan blast use about 4% of the steam generated in the boilers.

2. There was no clinker formed during the trial, as the

TABLE VII.—Trials of the Coxe Chain-Grate Stoker and Babcock & Wilcox Double-Deck Boilers.

Type of boiler	Double-deck Babcock & Wilcox.		
Kind of draft	Mechncl. draft with fan blast under fire.		
No. of trial	332	333	334
Duration of trial, hours	9	10	10
Dimensions and proportions:			
T'l water htg. surf. pr boilr sq.ft.	...	4,225	...
Area of grate, sq. ft.	...	68.9	...
Ratio, water-heatg. to grate surf.	...	61.3	...
Steam pressure by gage, lbs.	131.5	132.6	130.1
Force of draft in ins. in water:			
In stack, ins.	—0.13	—0.40	—0.58
In furnace, ins.	—0.10	—0.15	—0.24
In ash-pit, ins.	+0.24	+0.43	+0.68
Av. temperature, feed water, °F.	107.1	119.7	115.9
Escaping gases, °F.	439	547	533
Fuel: P. & R. C. & I. Co.'s anthracite	Buckwheat.		Rice.
Moisture in coal, %	0.7	4.3	2.5
Refuse in coal, %	17.2	18.8	21.6
Quality of steam, dry steam = 1	0.998	0.998	0.998
Water evap. per lb. of dry coal from and at 212° F., lbs.	9.36	8.92	7.91
Per lb. combustible from and at 212° F., lbs	11.31	11.00	10.08
Heating per sq. ft. of surface, from and at 212° F., lbs.	3.03	4.77	3.61
Dry coal burned per sq. ft. grate surface per hour, lbs.	19.8	32.9	28.0
Llb. coal per HP. developed, lbs.	3.68	3.98	4.36
Horse-power on a basis of 30 lbs. of water evap. per hr. from temp. of 100° F. into dry steam at 70 lbs. gage, HP.	370.4	581.0	442.3
Horse-power, builders' rating, HP.	375.0	375	375
% dvlpd above or below rating, %	—1.2	+55.0	+16.6
Sq. ft. of heating surface per HP. developed, sq. ft.	11.4	7.27	9.55

coal was what is known as "white ash." It is probable that the clinkering would not be serious with even Lykens Valley coal.

3. The fires resembled a puddling furnace. The furnace temperatures must have been nearly 2,800° F., over the two central blast compartments. Analyses of the flue gases proved that the combustion was good.

4. A most annoying and peculiar deposit of ash, etc., rapidly collected against the water tubes, due to the intensity of the blast in the two central compartments of Fig. 2. This deposit is not readily removed by a steam blast, but comes off with ease when scraped. The particles clinging to the tubes appear to have been fused. They much resemble the formations observed on boilers burning blast furnace gases.

5. The water-box furnace lining is an advantage when used in connection with an open feed-water heater, like the Webster, Hoppes, etc. Too much water for boiler-feed purposes was circulated on the test. If a water box is a necessity (the writer thinks it is not), it should be made strong enough to stand the boiler pressure, and to receive the feed water just before it enters the boiler. In this event pipes should be provided for an induced circulation when not feeding the boiler.

6. The stoker will quickly respond to sudden fluctuations in power demands.

7. The economic results obtained on the trials were good.

8. Crowding the fires produces but little reduction in the economy.

9. About three-fourths as much capacity can be developed with rice as with buckwheat coal, under like conditions, with this stoker.

10. More than ordinary care and skill is required in operating this stoker, on account of the graduated air blast used. This is specially true for a plant receiving mixed coal, i. e., buckwheat coal from different mines, or from different levels from one mine. Any inattention may result in too much or too little air being supplied over the last two, i. e., the burning-down and burning out compartments, or C and D of Fig. 2.

The Babcock & Wilcox Stoker.

General Description.—Like the Coxe, this stoker is of the chaingrate type. It is useful only for burning bituminous coal. It differs from the Coxe in many constructive features (see Fig. 3).

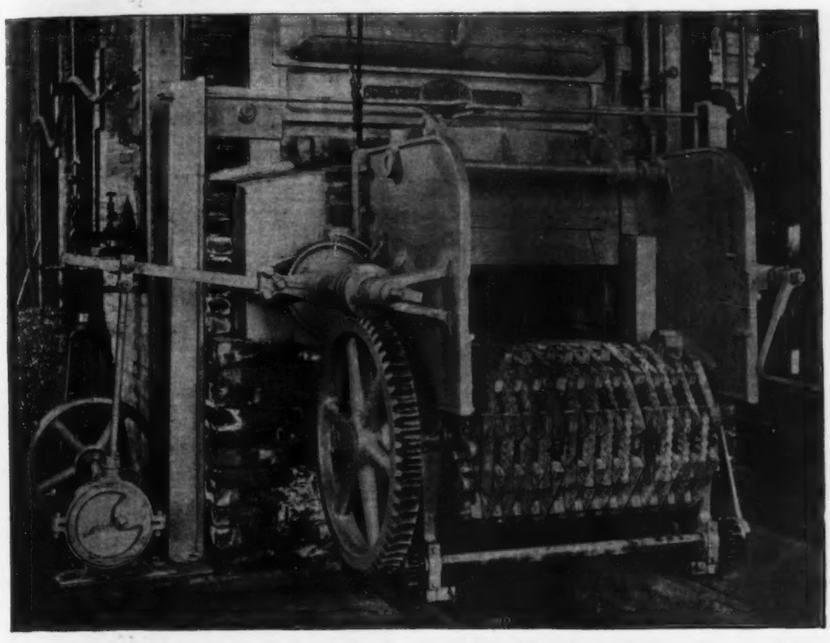


FIG. 3.—THE BABCOCK & WILCOX CHAIN GRATE STOKER.

TABLE VIII.—Babcock & Wilcox Chain-Grate Stoker Trials made with Bituminous Coals.			
No. of boiler test	330	331	278
Duration of trial, hrs.	10	10	8
Total heating surface, sq. ft.	2,758	2,758	2,789
Grate surface, sq. ft.	45.5	45.5	45.5
Ratio of water-heating surface to grate surface	60.6	60.6	61.3
Steam pressure, lbs.	87	85	98
Chimney draft, ins. of water	0.41	0.51	1.16
Furnace draft, in inches of water, ins.	0.26	0.34	0.61
Average temperature:			
Of feed water, °F.	154.7	152.3	38
Of escaping gases, °F.	365	388	538
Moisture in coal, %	3.63	3.38	4.00
Ash and refuse in dry coal, %	9.24	9.70	10.16
Moisture in steam, %	0.167	0.172	0.550
Water evaporated:			
Dry coal,* lbs.	10.67	11.01	10.70
Combustible,* lbs.	11.76	12.19	11.90
Dry coal burned, sq. ft. grate surface per hour, lbs.	18.4	24.9	33.2
Water evap.* hour per sq. ft of water-heat'g surf, lbs.	3.25	4.36	5.80
HP. on the basis of 30 lbs. water pr. hr. evaporated from temp. of 100° F. into steam at 70 lbs. gage pressure, HP.	259.5	348.2	468.8
HP. builders' rat'g, sq. ft., HP.	240	240	250
Developed above rating, %	8.1	45.1	87
Dry coal burned per hour per boiler HP. dvlpd, lbs.	3.23	3.13	3.22
Speed grate in ft. pr. hr., ft.	11.87	13.75	14.38
Kind of coal, slack from	"Columbian," W. Va.		Connellsville, Pa.

*From and at 212° F.

As used on the tests noted in Table VIII., the Babcock & Wilcox stoker had an active grate 78 in. wide by 84 ins. long, with 21% air openings for the boilers described in the sheet. The ratio of heating to grate surface was 60.6 for trials 330 and 331, and 61.3 for trial 278. The fires were carried 5½ ins. thick in front. The speed of the grate varied from 2¾ to 2⅞ ins. per min. Only natural draft was employed, and that was indifferent on trials 330 and 331.

Stoker Trials.—Table VIII. contains the results of three trials made on this stoker. Trial 278 was made jointly by Mr. Daniel Ashworth, of Pittsburg, and the writer. The economic results are ideal.

Summary Regarding the Babcock & Wilcox Stoker.—1. This stoker is smokeless when run as in the tests. It did not form a clinker, nor require the use of a firing tool.

2. It readily responds to fluctuating boiler demands, where the stack draft is good.

3. It, like the other stokers named in this paper, requires a strong draft, either natural, induced, or forced. The air openings in the grate are but about one-half of the extent usually found with stationary grates, hence a stronger draft is required than with hand firing.

4. A remarkable feature of the tests is that the boiler develops almost ideal economy when forced to develop an evaporative horse-power on 6 sq. ft. of heating surface. This is never realized with hand firing. The writer's experience is that when a boiler, rated on 10 to 12 sq. ft. to the horse-power, is forced to develop a horse-power on less than 8.5 sq. ft. of heating surface, the economy rapidly drops.

5. No charge can be made against this stoker for steam used, other than from 0.2 to 0.4% for driving the stoker engine.

General Summary.

1. Each stoker seems well adapted to the conditions for which it was designed.

2. Each stoker gives ideal economic results when properly handled.

3. Stoker engines use from 0.2 to 0.4% of the steam generated.

4. Fan blasts use from 3 to 5% of the steam generated.

5. Steam blasts use from 5 to 11% of the steam generated.

6. A defect, common to each of the stokers named in this paper, is a too scanty air space in the grate.

7. Neither stoker will develop as much capacity as will hand firing with stationary grates, having the same draft and coal conditions. Stokers, however, are not only more constant in the power developed, than is a hand-fired grate, but are more responsive to fluctuations in the power demands. The stoker is always in the condition that a hand-worked fire is in just after its cleaning, i. e., always clean and "ready for a pull."

DOES PURE WATER PAY?

The value of pure water cannot be expressed with absolute definiteness in dollars and cents, first because we cannot say just how many lives and how much sickness it saves, and second because if these facts were known their value could not be told in money terms alone. But while this is true some figures can readily be presented by the engineer and sanitarian, which may have good effect when water supply or sewage disposal problems are under discussion.

A good instance of what can be done in this line is presented by the following extract from a new book on "Water Supply," by Prof. Wm. P. Mason, of Rensselaer Polytechnic Institute, Troy, N. Y. Prof. Mason has made special studies of the relation between water supply and disease, both in this country and abroad. He writes, under the caption, "Does Pure Water Pay?" as follows:

To abandon an existing water-supply system, or to purify the polluted water that it furnishes, always involves the outlay of much money, and the city taxpayer has the right to inquire whether or not the benefit derived is a fair equivalent for the cash expended. Impure water affects the yearly death rate, as a whole, much less than that section of it which deals with diseases recognized as "water-borne," prominent among which is typhoid fever. No better measure can be selected of the wholesomeness of a city supply than that furnished by a list of the annual cases of this serious disease.

Typhoid fever is doubtless, to a very large extent, a preventable disease, but the means of prevention, in the shape of great public works, are expensive, and again the question is asked, Do these works pay? Can we afford to save the typhoid victims?

According to Rochard,

The economic value of an individual is what he has cost his family, the community or the state for his living, development and education. It is the loan which the individual has made from the social capital in order to reach the age when he can restore it by his labor.

The statement of this value in the form of money is a difficult matter which has been variously settled by sundry investigators. Chadwick considers an English laborer equivalent to a permanent deposit of about $980. Farr gives about $780 as the average value of each human life in England. A French soldier is rated as worth about $1,200.

In view of the fact that typhoid fever selects by far the greatest number of its victims from among those in the very prime of life, to the relative exclusion of the very young and the very old, it will be reasonable to follow the figure fixed upon by E. F. Smith, and place the loss caused the community by a death from typhoid at $2,000. This will be noticed to be less than half the figure so frequently referred to in the courts of this state, for the value of a human life.

For the sake of illustration, let us consider the tax levied annually by typhoid fever upon a city of one hundred thousand inhabitants; for instance, Albany, N. Y. From statistics given in the last five annual reports of the State Board of Health, the deaths due to typhoid fever in Albany average 75 for the year. Rating the money value of each life at the figure given above, this death rate would mean an annual pecuniary loss to the city of $150,000. Funeral expenses are variously estimated at from $20 to $30. Should we accept the intermediate value of $25, this item would cause $1,875 to be added to the above sum, thus raising the total direct loss through death to $151,875.

But typhoid fever does not always kill. Its mortality rate is commonly quoted at about 10%. For the present purpose, should we assume nine recoveries for each death from the disease, and place 43 days as the period of convalescence (the average of 500 cases at the Pennsylvania Hospital), we should have a term of 29,025 days as representing the time lost, per year, by the 675 persons who have the fever and recover. Thus an annual loss of over 79 years has to be borne by the city's capital of productive labor.

This great amount of enforced idleness, when translated into money value, should very properly be added to the death loss above estimated.

Fixing the rate of wages at $1 per individual per day, a very low figure, considering that the bulk of typhoid patients are in the very prime of life, there is a loss of $43 of wages for each recovery, or a total yearly loss for the

city from this item of $29,025. The cost of nursing and doctors' bills equal at least $25 per case, which is a very low estimate, thus adding the further amount of $16,875 to the gross sum. Expressed in tabular form, this yearly tax imposed by typhoid fever upon the city of Albany is given below, and, upon a most conservative estimate, it is practically $200,000, which is $2 a year for each man, woman and child in the city, or a yearly tax of $10 for every family of five persons:

75 deaths, at $2,000 each	$150,000
75 funerals, at $25 each	1,875
Wages of 675 convalescents, during 43 days, at $1 per day	29,025
Nursing and doctors' bills for 675 convalescents at $25 each case	16,875
Total tax levied annually by typhoid fever upon the city of Albany	$197,775

It can readily be seen that public works which could eliminate a reasonable fraction of this great tax would pay for themselves in the course of a few years, even though they were originally expensive.

Finally, it is right to inquire what fraction of the present typhoid loss it would be reasonable to hope to save if pure water should be served to the city in place of its present polluted supply. To answer this question, recourse must be had to statistics obtained from other cities, covering periods before and after better water-systems had been introduced. Such data have been already given for a number of cities and communities, and it only remains to anticipate what will be later said of Munich, and state that improved water and sewerage have reduced the annual typhoid mortality from an average of 25.4 per 100,000 to 2.7.

Surely pure water pays in a city with such a record, and likewise it would pay in the newer, but growing, cities on this side of the Atlantic. Americans insist upon being supplied with much more water per capita than is usually furnished in Europe, but they are singularly indifferent as to its quality. It would be a reform of great moment if they could be induced to curtail the present enormous waste of public water, such as that of Buffalo for instance which is stated to be 70% of the entire pumpage, and to expend the money thus permitted to leak away in a vigorous effort to improve the quality of the water. No such lowering of the typhoid death rate as occurred at Munich, San Remo, and sundry other places could be looked for, perhaps, but a large percentage of the present rate could be cut off, and, we think, from a consideration of the above figures, that such a reduction would pay.

No weight should be attached to the argument, so often advanced by the individual householder, that he and his family "have used the water without evil results for fifty years." A single family is too small a collection of units upon which to base any estimate touching the question at issue.

Placing the typhoid death rate for Albany, as above, at 75 annually, it would call for one death in a family of five persons every 261 years, a period much beyond the limit of ordinary family record.

THE ST. LOUIS TORNADO.

Our readers are already familiar through the newspaper reports with the particulars of the great calamity which visited the cities of St. Louis and East St. Louis, on the afternoon of May 27; we note it here, therefore, merely to place on permanent record the chief particulars concerning one of the world's great disasters. In our next issue we hope to be able to present some notes of those features of the disaster of chief interest to engineers.

The storm which effected the destruction first broke upon the city at 5 p. m.; the wind then blew from the northwest at a rate which reached 80 miles an hour, and lasted from 5 p. m. to 5.20. This was a general hurricane, and while it did the damage which a wind of such velocity would be expected to, it was trifling compared with that which followed. At 5.20 the wind began to abate, and at 5.45 had fallen to only 6 miles per hour, and the sky was partially cleared. Soon, however, a great bank of clouds from the southwest rolled over the city and a little after 6 p. m. a tornado from the southwest struck the city and swept across it toward the river, leaving a wide track of destruction wherever it touched. At the river it demolished a great amount of shipping, and then crossing, ravaged dwellings and manufactories in East St. Louis. Fire naturally broke out among the ruins and with the fire alarm wire service ruined and the streets badly obstructed there was, of course, delay by the fire department in undertaking its extinction. The copious rain which accompanied the storm and continued for three hours (over 3 ins. being the total precipitation) fortunately aided in hindering the spread of the flames.

The property loss by the storm in the two cities was set by the St. Louis "Globe Democrat," four days after the storm, at $5,000,000. The loss of life will never be exactly known, as many dwellers in shanty boats on the river front were drowned, and their bodies were washed away. The best estimates, however, place the total for the two cities at 300 deaths. This makes the amount of destruction to life and property greater than that ever recorded in any tornado in this country. The Louisville tornado of March 27, 1890, in which 125 lives were lost and a property damage of $2,500,000 was done, ranks next to the St. Louis tornado in the extent of the calamity. The St. Louis "Globe Democrat" prints a summary of the loss of life by tornados during the month of May just past which shows a total of 430 lives, the chief sufferer besides St. Louis being Sherman, Tex., where 85 were killed on May 15. This estimate was made, however, before the full extent of the St. Louis tornado's work was ascertained, and it is probable that the total loss of life from tornados in the United States during May will exceed 600. The same tornado which struck St. Louis is estimated to have caused 60 deaths at other points in Missouri and Illinois.

Returning to the storm in St. Louis, the original reports of damages to the Eads bridge seem to have been largely exaggerated. The storm is said to have injured the masonry of one pier, and the carriage roadway and the railway tracks were blocked by wreckage. The bridge structure proper, however, appears to have suffered no injury. The interlocking plant of the Terminal R. R. Association was so badly damaged as to be put out of service for several days, which, of course, greatly interfered with the prompt movement of trains. A Chicago & Alton train which was crossing the Eads bridge at the time of the storm was derailed by the force of the wind, but the passengers escaped uninjured and no material damage appears to have been done to the bridge structure by the derailment.

The electric railway service of both cities was almost wholly suspended on account of blocked streets and damage done to circuits and to power houses. St. Louis is famous for its net work of overhead wires, practically nothing having been done there toward placing them underground, and the falling poles and wires were largely responsible for the blockaded streets and for not a few deaths. The electric light, telephone and telegraph service was entirely cut off over a large part of the city, and many days will be required to fully restore it.

The number of buildings in St. Louis badly damaged by the storm exceeds 1,200, according to a list published in the "Globe Democrat." A large proportion of the boats on the river front were torn from their moorings and carried down the stream.

Probably the man in St. Louis best known to our readers is Prof. J. B. Johnson, of Washington University, and his many friends will be glad to hear that while his residence was in the path of the storm and was badly damaged, he and his family escaped without injury. We extract the following from a personal letter just received from him:

> The storm area covered about 1 mile in width and 2½ miles in length of the portion of the city immediately south of the railway tracks and the old Union Station. My home on Russell Ave. was rather in the southern part of the belt, but nearly all the houses on this street were more or less demolished, every one being injured, and a few being entirely razed to the ground. My own house lost all the roof and the third story, and all the window glass.
>
> The family were on the second floor in the rear when the storm came, and remained there until the worst was over, when they escaped to the cellar. None of them were injured, as this part of the house has but two stories, and the roof did not come off. I, myself, was at Washington University, 2¼ miles away, and was unaware of any such accident until I reached this part of the city on my way home, afoot, some two hours later. The destruction of property would seem to a casual observer to be almost complete, but it is, I think, much less than it would appear. Nearly all the roofs are gone in this whole area, the top stories more or less injured, and about one house in twenty, perhaps, will have to be rebuilt from the foundation.
>
> Lafayette Park, covering about 36 acres, which has been long recognized as the most beautiful small park in America, if not in the world, seems to have been about the center of the storm area, and it was entirely stripped. The stumps and remains of trees which are left stand like skeletons and ghosts, since many of them have even lost their bark.
>
> All of the public institutions in our part of the city also, in which I am particularly interested, were partially or wholly demolished, but the University buildings were untouched. There was so little loss of life compared with the destruction to property, that we all feel that we have more to be thankful for than ever before in the world. Amongst all my large circle of acquaintances is that part of the city, there is not a single fatality, and exceedingly few personal injuries of any sort. As a rule people sought safety in their cellars, and these have proved a very safe reliance.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Transfers on Street Railways.

If a street railway company has established by its practice a right in its passengers to change without a transfer ticket from one car into another on the completion of their journey, it cannot change such practice without due notice, and a passenger who is ejected from a car after having made a transfer according to former practice has a right of action against the company.—Consol Traction Co. v. Taborn (Supr. Ct., N. J.), 32 Atl. Rep. 685.

Injury to Street Car Employee.

An employee of a street car company who was crushed between cars passing on the switch and main tracks while standing there to change the switch is not guilty of contributory negligence where it appears that this position is the one usually taken, and not in itself a place of peril.—Gier v. Los Angeles Consol. Elec. Ry. Co. (Supr. Ct., Cal.), 41 Pac. Rep. 22.

Certificate of Engineer as to Completion of Contract.

A contract for the construction of a bridge provided for payment on certificate of the engineer that the work had been completed. After the bridge had been practically completed, the contractor demanded payment, and the engineer wrote the owner that the bridge was completed except for some planking which could not be done until low water; that he was willing to accept the bridge as it stood, and advised the owner to retain a certain amount of the contract price to secure the completion of the planking. Held, that such letter entitled the contractor to the payment of the price, less a sufficient sum to insure the completion of the planking.—Washington Bridge Co. v. L. & R. Imp. Co. (Supr. Ct., Wash.), 40 Pac. Rep. 982.

Conflict between Notes and Monuments.

Where there is a conflict between field notes and monuments, the field notes must yield to the latter. Where stakes are found at points so as to conflict with the field notes, the burden of showing that the stakes were monuments of the original survey is on the party claiming as to the stakes.—Robinson v. Laurer (Supr. Ct., Ore.), 40 Pac. Rep. 1,012.

Powder Mill a Public Nuisance.

A mill manufacturing powder and other explosives, and storing the same on the premises, situated on the bank of a river and near two railroads and a public road, is a public nuisance, and any one injured in property by explosion of powder stored there may recover damages without proof of negligence in its operation.—Wilson v. Phoenix Powder Mfg. Co. (Supr. Ct. of App. of W. Va.), 21 S. E. Rep., 1035.

Corporation Franchises Held Subject to Condemnation by Eminent Domain.

Act 1,894, No. 162, authorizing a street railway company to acquire by condemnation an easement in the roadway of a turnpike company, for the operation of its railway, is not unconstitutional, in that it violates the obligation of contracts, as corporations hold their franchises subject to the right of eminent domain.—Prest., etc., of Baltimore & P. Turnpike Road v. Balto. C. & E. M. P. Ry. Co. (Ct. of App., Md.), 31 At. Rep., 854.

Control of Trees in Streets.

Trees growing in a city street are under control of the city, and it may have them cut down, in order to make room for a sidewalk, even though the fee of the street does not belong to the city.—City of Mt. Carmel v. Shaw (Supr. Ct. of Ill.), 39 N. E. Rep., 584.

THE WEMBLEY PARK TOWER, near London, England, which is to be 1,150 ft. high, or higher than the great Eiffel tower, is now completed to the first stage 160 ft. from the ground (400 ft. above sea level), and this stage is now open to the public, being reached by two steam elevators carrying 55 persons each. The area covered by the base of the tower is 204 × 280 ft. Work is now in progress towards the second stage, 300 ft. above the ground.

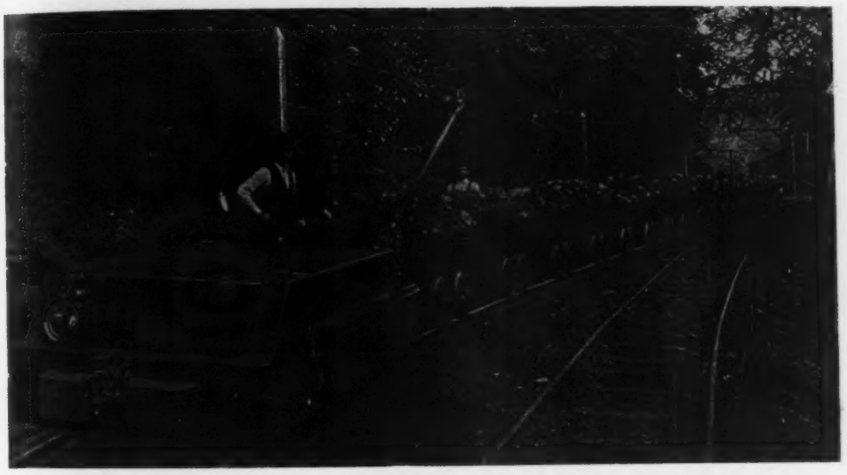
THE PALISADES OF THE HUDSON RIVER are to be protected by the state of New Jersey from further destructive quarrying. According to report Governor Griggs has directed the Attorney-General to begin proceedings for an injunction against Brown & Fleming to restrain the firm from quarrying stone from the face of the Palisades. This is based on the law of 1894, concerning the Riparian Commission. It will make a test case. The commissioners have hitherto refused to act, as they held that their power did not extend to the face of the cliffs.

A STREET CAR STRIKE at Milwaukee is becoming notable on account of the extensive and unprecedented use of the boycott by the strikers and their sympathizers. The workmen originally struck for an increase of 1 ct. an hour in wages and the right to recognition as a labor union. The company refused their demands and in the course of a week was able to secure men enough to run most of its cars from outside sources. Then a boycott was declared and from the fact that the street car company was extremely unpopular with the citizens of Milwaukee, it has been put into effect with a vigor that, according to all accounts is quite unparalleled. At latest reports the company was running cars almost empty on all its lines save one. It is stated that at least three-fourths of the population openly sympathize with the employees and support the boycott; and a large portion of the remaining fourth dare not use the cars for fear of a boycott on themselves.

ELECTRIC PLANT OF THE YOUGHIOGHENY RIVER COAL CO.

The Youghiogheny River Coal Co. has for some time been using electrical power for operating locomotives, coal cutting machines, etc., in its various mines in the neighborhood of Scott Haven, Pa. The power plant consists of three automatic engines, with cylinders 15×16 ins., and 6 ft. flywheels, running at 240 revolutions per minute. Each engine is belted to a four-pole General Electric generator of 100 K-W., making 650 revolutions, wound for 500 volts and over-compounded for 10% less on the line. There are three independent tubular boilers, 5½×18 ft., built by the Union Iron Works, of Erie, Pa., and supplied with water from a well 130 ft. deep by a Downie deep-well pump.

The switchboard is divided into two parts, one for the generators and one for the feeders. The



ELECTRIC HAULING AT THE MINES OF THE YOUGHIOGHENY RIVER COAL CO.; SCOTT HAVEN, PA.

arrangement is such that the plant may be run under the best conditions for economy, and every precaution is taken against stoppage. There is a grounded circuit for the haulage work and a metallic circuit for the fans, coal cutters, etc. Any dynamo may be run on either of these circuits. From the power house the circuits for No. 1 mine are run on poles to the mouth of the mine, a distance of about 900 ft. This mine has a Capell exhaust fan, 8×3½ ft., running at 280 revolutions, and driven by a belt from a 25-HP. multipolar motor running at 650 revolutions. The coal cutter is a Jeffrey undercutting chain machine, 1¾ miles from the power house. There is also a Knowles triplex pump, 6½×8 ins., driven by a multipolar motor of 7½ HP., the pump and motor being mounted on an iron truck which can be run to any part of the mine. The electric locomotive in this mine runs on a track of 43½ ins. gage, laid with 30-lb. rails, and has a length of haul of 1¼ miles, the grades varying from 1% against the load to 0.25% with the load. At the tipple of this mine is a motor of 7½ HP. driving a revolving screen and an emery wheel for sharpening bits. For each of the other mines the current has to be carried under the Youghiogheny River by cables to a small cable house, from which lead the lines to the different mines. In the Pacific mine is a pump similar to that in No. 1, driven by a motor of 7½ HP., and placed about 16,000 ft. from the power house, while a fan with a motor of 30 HP. is placed about 1,000 ft. beyond the pump. The locomotive in this mine exerts a drawbar pull of 2,500 lbs., and has a length of haul of 7,000 ft. underground and 800 ft. in the open. In the Southwest mine and in mine No. 4, the current is used only to drive multipolar slow-speed motors of 7½ and 10 HP. for triplex pumps similar to that in No. 1, these pumps being 8,000 ft. from the power house. Electrical apparatus is also being fitted in mine No. 5.

The two locomotives have taken the place of 18 mules and their drivers. The four pumps, which require the partial attention of three men, have taken the place of 2 steam pumps, 2 boilers, 10 men and 4 mules. The power plant and all the apparatus were furnished by the General Electric Co., of New York.

ANNUAL CONVENTION OF THE AMERICAN WATER-WORKS ASSOCIATION.

The sixteenth annual convention of the association was held at Indianapolis, Ind., May 26, 27 and 28, and an unusually long list of papers and reports were presented and discussed. Indeed, the length of the program compelled the association to read several of the papers only by title and to cut short the discussion in several instances. A critical observer might also complain of some waste of time in irrelevant and digressive discussions, but on the whole it is probable that the, at times, rather informal method of proceeding helped to bring out the opinions of some members who might not have spoken otherwise. The general expression of the members was that the convention was a most successful one in the amount and character of the work done.

At the opening session the attendance was not large, but it increased considerably during the day, as members arrived from distant points, and by Wednesday from 200 to 250 members and guests were present. The various manufacturers of water-works supplies were well represented and many had more or less complete exhibits of their apparatus, as is noted more at length on another page of this issue.

Owing to the death of President G. W. Richards, of Atlanta, Ga., shortly after his election last May, the chairmanship of the convention devolved upon First Vice-President Mr. F. A. W. Davis, of Indianapolis, Ind., who opened the first session by introducing Gov. Claude Matthews, of Indiana, who delivered a short address of welcome. Gov. Matthews' address was followed by a few remarks by Mr. Thomas Haggart, Mayor of Indianapolis. Acting President Davis then gave his opening address, in which he called attention to the importance to the people of the daily duties which the members of the association had to perform. He urged that constant study be given to all progress in this line of the municipal mechanism, and stated that to this end the association should establish permanent headquarters and collect a library. This would require money, but he believed that it could be raised by increasing the dues slightly and developing the interest of water companies and the municipal water-works officials. In closing, Mr. Davis referred briefly to the death of Mr. Richards. At the close of the President's address, a memorial to Mr. Richards was presented by Col. L. H. Gardner, and a series of resolutions passed in his memory, after remarks by a number of members.

The Secretary, Peter Milne, announced that there were before the association 36 applications for membership, and after some discussion as to the proper manner of election, the Secretary was ordered to cast a ballot for all the names presented. The convention then proceeded to the reading and discussion of papers.

The first paper read was by Mr. L. N. Case, of Detroit, Mich., and was a continuation of a former paper. It was in substance as follows:

Water-Works and Their Management.

These questions naturally arise in considering the subject of proper water supply:

From what source, or in what manner, shall we raise the revenues necessary for its construction and operation, and how shall we make the sums so required as small as is possible? The system that I shall advocate is in accord with the principle that the cost of consumption should fall upon the consumer, and is the only system that furnishes a means by which waste can be prevented. It is as follows:

1. To the extent that the water supply of a community is a protection to property—satisfies a public necessity—and conduces to public enjoyment, it should be paid for by the public, and to that end be imposed, with other taxes, upon the property.

2. To the extent that it is necessary and desirable for business or domestic purposes, it should be paid for in proportion to the quantity one uses or permits to run to waste.

3. To the extent that unoccupied property forces an expense in the laying of mains by it in order to reach the occupied portions, to that extent should the unoccupied tracts be obliged to pay.

It is not difficult to tell approximately what proportion of the expenditures for constructing and maintaining a water-works comes under the first statement. The water that is lost in transit through leaks in force and distributing mains, together with that used in the suppression of fires, with that used for other public purposes and needs, with that used in public parks, fountains, etc., and with that used for charitable purposes, constitutes about 25% of the whole supply. Then, one-fourth of the revenues required to maintain and operate a plant should be included in the general tax levy.

Upon the second statement depends not only the principle of personal responsibility, but the only means of preventing wanton waste. When it is understood that 60 gallons daily per capita is a reasonable supply for all the uses of a community, and that where no restrictive measures are adopted, this supply gradually increases to three, four and five times this amount, and this without accomplishing any good whatever, but, on the contrary, forces the expenditure of large sums for construction, operation and maintenance, it certainly seems that there is a demand for retrenchment and economy. Were every one in a community equally responsible for their joint waste and extravagance, and were it otherwise arranged so that the burden of this expense rested proportionately upon those who caused it, it would not be necessary to introduce restrictive measures, as that very condition would cause a cessation of the waste. Experience teaches us that in communities where this personal responsibility is least regarded, that the operation and maintenance of their water supply not only costs three or four times as much, but that the same looseness and irresponsibility permeates the whole fabric, rendering it more imperfect and unsatisfactory than in communities where it prevails.

In the establishment and operation of a water-works, there is nothing so important, or that requires more careful study, than its schedule of rates. That it should be equitable beyond all question, and that in its application all consumers be treated impartially, seems to me to be indisputable. That the rate upon which the schedule is based should be as low as circumstances will permit is also conclusive. I have never held that this schedule could, by any possibility, be the same for different cities, although I have strongly advocated their being upon a common basis and that basis the quantity of water consumed and the cost of supplying the same.

I have never believed in a sliding scale, or what I call an aristocracy of rates, especially when the plant is owned and operated by the community itself. A private water company may be justified, in a certain sense, in charging large consumers less per unit than the smaller, because the works are supposed to be operated at a profit. It is always considered good business policy to reduce this profit in making large sales. But a community that is operating a works for itself is certainly supposed to do so without a profit; that is, it calculates to receive from the consumers, if no appropriation is made from the general tax levy, sufficient only to meet its obligations.

All of the expenditures for the construction of a plant, and nearly all for its operation, depend simply upon the quantity of water that is required by the community. The fact that A upon Lot 1 uses 1,000 gallons a day, and that B on Lot 2 uses 100 gallons, has nothing whatever to do with these expenses; 1,100 gallons must be sent to that immediate locality each day, each gallon costing the same. The fact that A and B are partners in establishing and maintaining the works for their mutual benefit makes it more palpably unreasonable and unjust for one to pay less than the other for the same quantity. Of course, a minimum rate should be established that will satisfy the works for services rendered independent of the supply, such as the use of the meter, its repairs, the reading of the same, etc.

This principle of equity should also prevail in establishing "assessed" and "meter" rates, to the end that they may be made to correspond; that is, that neither the assessed or the metered consumer shall pay more for the same service than the other. In conclusion, I desire to say in connection with the subject of waste, that it seems to me more necessary to prevent wastefulness and extravagance in the conduct of our public affairs than it is to prevent it in our stores, our factories or our homes, because the burden of this expense, or a large share thereof, falls upon many who can ill afford it and who are not responsible for it.

The brief discussion which followed this paper was a good illustration of the desirability of having the papers of the association printed and distributed in advance of the convention, for it turned upon a cursory remark in the paper as to the cost of supplying water and was largely irrelevant to the main arguments of the paper. Mr. S. Bent Russell, of St. Louis, Mo., stated in confirmation of Mr. Case's views, that a study of water consumption in America impressed the necessity of checking or reducing waste, and expressed his belief that it would pay any city to introduce meters.

The next business was the reading of the report of the Committee on Animal and Vegetable Growths Affecting Water Supplies, by Prof. Albert R. Leeds, Stevens Institute Technology, Hoboken, N. J. The following is a very brief abstract:

Growths Affecting Water Supplies.

Many of the phenomena connected with the production of tastes and odors in water have their origin in the life processes of animals and plants that are still quite unknown. A vast amount of pure scientific work, therefore, has to be done before the information necessary to the best practical results will be available. To conduct this work would require for the committee the services of a

biologist, a chemist, an engineer, a draftsman, one or more field assistants and a working laboratory and library. It was not likely that the association would assume so great an expense, so that it was necessary to turn to other means, leaving to the committee the duty of fostering such investigation by such aid as would not require a large financial outlay. Fortunately there were scattered throughout the country institutions of learning where not only chemists but botanists and biologists were found who could be profitably interested in this work. Similar aid could be obtained from boards of health, and from independent investigators.

Turning to the practical use of such information as was available, Dr. Leeds then spoke of the environments and conditions under which algae were the most rapidly produced, giving results of practical experiments made by himself. He found that they grew most rapidly in sunlight and at summer temperatures. "If the object, therefore," he continued, "is to prevent the formation of algae, as is the case with pure subterranean waters, from wells or filtering galleries, or filtered water, if water is to be got with the least possible change directly to the consumer, the practice of keeping it in cold, dark reservoirs is to be commended. In England this has been the practice for the past 30 years, but in this country the covering of reservoirs, many placed above ground in a slight and imperfect manner, has often kept the water neither cool nor free from dust or dirt, nor dark, and some of the contradictory opinions on this subject may be connected with this inadequate protection.

"The preservation of filtered or subterranean water, however, is a very different question from that of surface waters impounded on a large scale. Covering being impossible, the first expedient has been to cut off the amount of food-supply. The failure to remove the decomposed organic matters at the bottom of the reservoirs has been a prolific source of trouble. The flowage of shallow areas around reservoirs, especially when alternately dried up and exposed to the sun, results in the formation of what might be termed forcing houses, or hot-houses, where every variation of light, temperature, moisture, sustenance, etc., is brought into vigorous play to originate and foster the growth of as many varieties and as large an amount of animal and plant growths as possible."

In the discussion which followed, Col L. H. Gardner, of New Orleans, and Mr. Wm. B. Bull, of Quincy, Ill., made vigorous pleas for the continuation of the committee and, upon motion, the committee was instructed to formulate plans for the future, embracing a report of the amount of money that would be necessary to carry on its work. The paper was the signal for the relation of a number of personal experiences of members of the association who had met and fought with the enemy, algae, or vegetable growth. Mr. C. P. Allen, of Denver, had found that lining reservoirs with different substances had but little effect in remedying the evil. After a number of experiments he discovered that sunlight aided the growth. By covering the reservoirs, so that every ray of sunlight was excluded, the growth ceased and the water was pure and wholesome. Mr. S. A. Charles, of Lexington, Ky., showed a sample of water highly polluted with vegetable growth. His remedy was to thoroughly filter and aerate the water. This, together with the exclusion of sunlight, secured highly satisfactory results, as was shown by a sample of water in a clarified state. Mr. Allen explained further that the kind of water used made no perceptible difference in vegetable growth, as it was just as great in water from an artesian well, 700 ft. in depth, as in the water from wells, which derived their source from the river, after filtration through beds of sand. Following the discussions of Dr. Leed's paper, Dr. J. N. Hurty, of Indianapolis, read a paper on the "Water Supply of Indianapolis."

Dr. Hurty's paper was a brief historical description of the development of the water supply for Indianapolis, and was chiefly important for its description of the manner in which pollution at different times had been caused. The pollution of the private well supply, with which the waterworks company has nothing to do, has been caused by sewage, due to an insufficient sewerage system which is gradually being extended and improved. The supply furnished by the water company up to April 20, 1896, had never been questionable, but about that time developed evidences of pollution. This was found to be due to the fouling of the river waters, from which part of the supply is drawn, by vault cleaners who had dumped the contents of their tubs into the water. This cause of contamination was removed and it is expected that this, the first instance of pollution of the public water supply, will soon be only a matter of history.

There was no discussion of this paper, and adjournment was taken until the evening session, which was devoted to the presentation and discussion of subjects not on the program. Perhaps the one subject of most general interest discussed was the tuberculation of cast-iron water mains. In this discussion, little was presented that is new to our readers. It was the general opinion of those most familiar with the subject that the only preventative was a thorough coating of the pipe so that the water could not attack the iron, and that when tubercules were formed, scraping was the only means of removing them. Mr. Charles Hermany stated that he had been very successful in removing the tubercules from 20-in. mains by sending through them wooden cubes with attached lead weights at the opposite corners. These weights made the cubes turn over and over and wobble about enough to act very effectively on the sides of the pipe.

Wednesday's Session.

The first business at the second day's session was the reading of a paper entitled "Health Improbable, Economy Impossible, Without Filtration and the Meter," by Mr. J. B. Rider, of South Norwalk, Conn. The author advocated the use of both filters and meters and based his arguments upon statistics collected from a large unmber of cities. He stated that with the present conditions of water waste the use of meters would save enough to pay for the construction and operation of filters. There was no discussion, and the paper by Mr. Jacob P. Dunn, entitled "Out of the Ordinary," was read by the author. This paper was a consideration of the subject of how to make water companies pay taxes and supply pure water, and was after the Mark Twain order of argument and illustration. His thrusts at private water companies were generally enjoyed and he was given a vote of thanks for bringing to the attention of the representatives of such companies two things, which, as he remarked, "had never been considered by them."

The next paper was by Mr. Allen Hazen, and was on the "Filtration of Public Water Supplies." It was largely historical in character. The discussion was postponed until later in the day, but it will be given briefly here. Mr. Charles, of Lexington, Ky., spoke in favor of mechanical filters, which he favored because they could be constructed and operated more cheaply than sand-bed filters. He explained the system in use at Lexington (Eng. News, May 28),where, he said, water was filtered at the cost of less than $6 for a million gallons, notwithstanding the high price of coal. By a system of aeration, including, when necessary, the injection of live steam, all bacteria was destroyed. Prof. E. G. Smith, of Beloit College, said that he gathered from Mr. Hazen's paper that the latter favored sand filtration in preference to mechanical and asked what criterion he adopted in deciding that sand filtration was better. Mr. Hazen replied that he feared that some misapprehension was caused by his paper, and said that he was particular not to express himself as favoring one system in preference to the other. The criterion by which to judge would vary, according to environments of different cities. If water from one source of supply was polluted with algae or bacteria, that would be the fact to consider, rather than the subject of clarification. Mr. S. Bent Russell, of St. Louis, said that they had been making experiments, and that they were hampered by the lack of data as to results obtained with mechanical filters. This brought Mr. Wm. B. Bull to his feet. He said that but for the fact that he was under bond not to reveal what his filter company was doing in the way of making experiments at Louisville, Ky., he could give some valuable information as to what could be accomplished with mechanical filters. By way of a hint, however, he said that his company, acting upon the knowledge gained by experiments at Louisville, had undertaken to purify the Ohio River water used by one town under a guarantee to relieve it of 97% of bacteria.

Dr. Albert D. Leeds gave his personal experiences in experimenting with mechanical filters. In the operation he had lost the savings of a professional career of 20 years. He had not lost faith in the possibility of mechanical filtration, however, and felt that in the future, as a result of the experiments of the last ten years, a system would be evolved that would be better and cheaper than the old sand-bed filters. Mr. Hermany, of Louisville water-works said that he felt that an explanation was due from him why the filter companies making experiments at his plant had been bound to secrecy as to the results of those experiments. The plan was adopted in order to insure absolute impartiality and fairness in the experiments.

Upon the conclusion of Mr. Hazen's paper the convention proceeded to the election of officers, as follows: President, Mr. F. A. W. Davis, of Indianapolis; Vice-Presidents, John Caulfield, St. Paul, Minn.; J. A. Bond, Wilmington, Del.; C. P. Allen, Denver, Colo.; W. H. Laing, Racine, Wis.; and R. M. Clayton, of Atlanta, Ga. Secretary and Treasurer, Peter Milne, of New York. Finance Committee, D. R. Gwinn, Quincy, Ill.; G. H. Benzenberg, Milwaukee, Wis.; and W. H. Laing, Racine, Wis.

At the opening of the afternoon session a paper upon the "Evil Effects of Politics in Water-Works Owned by City Governments" was read by Mr. W. L. Cameron, of Kansas City, Mo. Mr. Cameron argued the pernicious effects of partisan politics management and the necessity of change. No discussion followed, and Mr. W. H. Laing, of Racine, Wis., presented his paper on "Our Experience With Automatic Flush Tanks." The paper stated that the automatic flush tank had been gradually introduced until there were now in operation 111 on 48 miles of sewers, or one tank for 2,282 lin. ft. of sewer. When the first tanks were put in, the effect on the supply of water was not noticeable, but as they increased in number, the demand upon the daily supply was extremely noticeable, and as the demand increased at an alarming rate it was quite obvious that something should be done about it at once. Upon mentioning the case to the city authorities, they of course said, "You must have a leak somewhere." This was all the satisfaction obtainable from them and the water was still running away at a great rate. Being convinced that a vast amount of water was running into the sewers through the automatic flush tanks, that four-fifths of it was literally wasted, it was then decided to test the supply and discharge of these tanks and determine exactly what they were doing. The tanks are connected with the street mains by ½-in. taps in the main and 1½-in. lead conveying pipes, with a ½-in. faucet, supposed to be curbed down to an economical discharge. A record of the location of each tank was kept, together with the number of times each one discharged in 24 hours, the number of gallons per discharge, and the total number each tank discharged in 24 hours. While it was expected that the quantity of water used by these tanks daily was large, yet the actual quantity was so greatly in excess of any guess-work calculation previously made, that it produced something of a sensation in the office when known. The tanks hold a varying quantity of water, from 183 to 308 gallons, and were found to discharge from 9 to 144 times in 24 hours, showing a total consumption of 1,436,429 gallons of water per 24 hours, and an average discharge of 23,877 gallons.

The paper was quite vigorously discussed by a number of members, each of whom had a story of trouble to tell. The gist of the discussion was that flush tanks could not be depended upon to work as designed, but made numerous discharges and consumed an immense amount of water to no necessary purpose. Prof. A. N. Talbot, of Champaign, Ill., considered that if this was the case it was due to improper construction. He knew of flush tanks which worked regularly and accurately, and if proper care was taken in their construction and operation they were not only valuable but in many cases necessary.

This discussion closed the business proper of the second day, but in the evening lectures, illustrated by lantern views, on "Water Supplies in Egypt" and "Water Supply and Distribution, City of Brooklyn, N. Y.," were given respectively by Mr. James P. Donahue, of Davenport, Ia., and Mr. Peter Milne, of Brooklyn, N. Y.

Thursday's Session.

The opening of the third and last day's session found besides the regular allotted business a considerable amount of work left over from the preceding sessions, and the result was that several of the papers received short shrift. The secretary reported that the finances of the association were in good shape, there being a balance of $316 in the treasury after paying all expenses for the year 1895. He also reported that the executive committee had decided to make the dues $5 for the coming year.

Owing to the postponement of Prof. Stanley Coulter's illustrated lecture on "Vegetable Growths in Water," which was to have been given the preceding evening, Prof. Coulter gave a brief verbal abstract of his paper. Like the weeds in a garden, he said, vegetable growths in water were interesting to water-works managers, not for their scientific classification, and life history, but because they were nuisances to be got rid of. All that was necessary to know then was the conditions that promoted their growth, and to take steps to make these conditions less favorable. Sunlight, warm temperature, adequate food supply, and favorable depths of water and condition of bottom were the things which favored rapid growth. Excluding the light, reducing temperature, keeping the depth of water great and having clean reservoir bottoms would prevent to a large extent injurious vegetable growths.

Mr. Dow R. Gwinn, of Quincy, Ill., then presented his paper on "Legal Decisions and Legislation," which was largely a digest of decisions affecting water-works management and construction handed down by various courts. The following papers were read by title and ordered printed: "Best Method of Setting Meters," by Mr. H. M. Lofton, Savannah, Ga.; "Laying Water Mains," by Mr. J. H. Decker, Brooklyn, N. Y.; "The Meridian Case," by Mr. W. B. Milner, Birmingham, Ala.; and "Asphalt Lining for Old and New Reservoirs," by Mr. L. J. Le Conte, Oakland, Cal.

"The Evolution of Water Supplies" was the title of a paper then read by Mr. J. T. Fanning, of Minneapolis, Minn. Mr. Fred Crosby, of Montgomery, Ala., then presented a paper entitled "Litigation at Montgomery, Alabama," and this was followed by a paper on "Lowering Water Mains Under Pressure," by Mr. D. W. French, of Hackensack, N. J. This paper referred especially to the lowering of 1,100 ft. of 20-in. main under a pressure of 120 lbs. at Hackensack, N. J. The work was accomplished by lowering 300-ft. sections at a time. There was practically no loss of water, the only escape being when bends were made too quickly.

This closed the work of presenting and discussing the papers and reports on the program, and the next business was the selection of a place of meeting for the next convention. Detroit, Mich., and Denver, Colo., were the places most strongly advocated, and it was decided to go to Denver upon a vote of 61 to 43. In the evening a reception was given to the members of the association by the Commercial Club of Indianapolis, Ind.

One of the papers on the program, to which reference has not been made above, was by Prof. E. G. Smith, of Beloit, Wis., on "Seasonal Fluctuations in Running Streams." The fluctuations considered were the chemical ones found during a number of years past in the Mississippi River water at Davenport, Ia., and were incident to the study of mechanical filtration at that place. The results of the studies thus far made indicate that certain variations may be expected to occur at about the same time each year, or with changes in precipitation and temperature. In so far as these changes can be anticipated preparations for treating the water accordingly can, of course, be made.